A NATURALIST AT THE SEASHORE

WILLIAM
CROWDER

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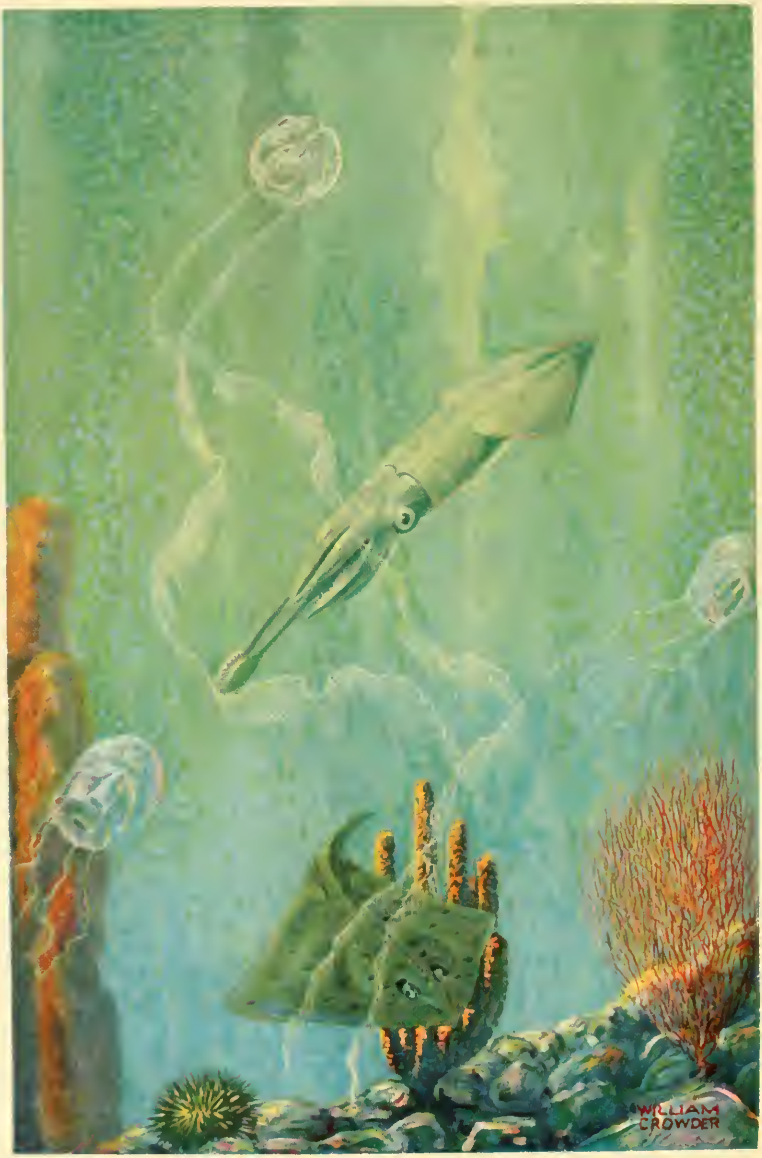
WILLIAM CROWDER

FLOOR OF LONG ISLAND SOUND

FLOOR OF LONG ISLAND SOUND

Pleurobrachia: a comb-jelly (upper-left)
Loligo: a squid (upper-middle)
Sarsia: a hydroid jellyfish (lower-left and middle-right)
Raja: a ray (lower-middle)
Arbacia: a sea-urchin (bottom-left)

A NATURALIST AT THE SEASHORE

BY WILLIAM CROWDER

ILLUSTRATED BY THE AUTHOR

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To

MY FAITHFUL ASSISTANT

which is to say, Elizabeth, my wife;

and to

E. GRACE MANN

mentor of my early days

FOREWORD

With the exception of a part of the text of "Aurelia: A Monograph of the Moon-jelly," the material in this book is here published for the first time.

"Aurelia" first appeared in "The National Geographic Magazine" under the title of "The Life of the Moon-jelly." It has since been revised and expanded.

I hereby acknowledge my thanks to the Editors of the forementioned magazine for their generous permission to make use of this article.

The entire action of this book takes place along the shore of Long Island Sound, in the vicinity of Glen Cove, L. I., less than twenty miles from the metropolitan district of NewYork City.

W. C.

Glen Cove, L. I.,
New York.
July, 1928.

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A NATURALIST AT THE SEASHORE

CHAPTER ONE

A Seashore Laboratory

I

IF you, perchance, be one of those in whom the drama of Nature has instilled a yearning to penetrate the labyrinths of its esoteric plot; one in whom there dwells that desire to reveal at first hand, or even vicariously, somewhat of the mystery of that strange world just outside the door; one in whom the love of living things—however lowly these may be—is of that order which urges to a deeper, sweeter understanding: then, Reader, you, more than any other, are privileged to appreciate the significance of that sequence of events which one Indian summer day led to my renewed acquaintance with what is perhaps the weirdest inhabitant of the oceanic realm—a realm in which even many commonplace forms of its life are preëminently bizarre, ghostlike, or spectral . . .

The day whereof I speak broke bright and cool. Shadows shortened; and then the oblique glare of the rising October sun dissolved the mists still hovering in the cove.

On the wings of the early morning there had already arrived, from one of the rookeries of a Long Island forest, phalanx after phalanx of beach-combing crows: the first appearance of these local visitors who, now since they will no longer find their food in the woods and fields, continue daily until spring to haunt this friendly shore.

Disputing vociferously this invasion of what doubtless they held to be their rightful territory, were scores of gulls. Of course, in this sort of argument the crow easily outmatches the gull: it can talk louder and faster. Moreover, it is more cunning.

An instance of this presently occurred while I was idly observing the milling crowd through binoculars from the door of my laboratory. Occasionally a gull would rise into the air with a mussel or clam in its beak and, in accordance with its customary habit, would drop the mollusk from a height sufficient to fracture its shell on the gravel and stones below. Invariably, however, some sharp-eyed crow detected this maneuver and seized the shattered shell-fish ere its owner could retrieve it. Nor were these black pirates averse to engaging in an even graver form of robbery. For soon I saw a gull glide upward, holding in its mouth a small fish, when forthwith two crows flew in its direction. Whereupon, perceiving its pursuers, the gull immediately bolted its mouthful. But the tantalizing twain would not so easily be denied; with one accord they heckled and so beset the gull that it disgorged the fish and let it fall for the freebooting birds to eat.

It was then that I first became aware that something extraordinary was taking place at the water's edge. The increased commotion among the birds, and their concentration at a spot just beyond an eclipsing ridge of sand which forms a spit across the entrance to the cove, was in itself sufficient for me to become inquisitive. Indeed, these were signs that I could not well ignore; experience in these matters had long ago taught me that even lesser tokens augured that much therein might be utilized to the naturalist's considerable profit. But, also, I saw, sailing majestically in the upper reaches of the sky, a buzzard—a sight rather rare in these latitudes.

For a moment, I stood, admiring, engrossed, watching it as it started to describe the great spirals by which it slowly and seemingly without muscular movement descends . . . Not hesitating to gather together my camera and other collecting accessories—an operation usually merely mechanical, when I go on a beach exploration—I was off immediately in the dinghy which is always retained in readiness a few yards from my door.

My arrival at the scene was obviously disconcerting to the birds, for they flew away in flocks; but to me it was a promising event. For here I came upon a find of the very first order. It was as I had anticipated—the birds' behavior did not belie them: a windfall, so to speak, had been thrown up on the shore by the waves, and was left stranded by the receding tide. Yet it was of such a nature that even I, accustomed as I was to surprises continually experienced in my contacts with the creatures of the sea, could hardly suppress a gasp of astonishment.

It was a frog-fish, or angler, a species of *Lophius*, four feet in length; one of those grotesqueries of the deeper waters, wherein it would seem that Nature had for once overreached itself in attempting to produce the odd or unusual. The aspect of this creature bordered on the horrible. Its head, of enormous proportions, was little more than a huge mouth. In fact, the fish seemed at first sight to be all mouth—the belly and remainder of the body appearing as a mere appendage. Both jaws were lined with rows of long pointed teeth, exquisitely sharp and inclined backward. Absolutely nothing could escape serious mutilation when once caught in the labyrinth of that terrible maw. Another striking, if less terrifying, structural feature was the modification of the dorsal fin, which was produced into three long separated filaments along the middle of the head. The first, or forward, of these was the longest (about twelve inches), and it terminated in a leaf-like organ which was probably some sort of a lure wherewith the angler enticed its prey, or, what was more probable still, a tactile organ to detect the presence of its living food—such as it certainly would have been required to do in the dark depths which it obviously haunted.

I had beaten the buzzard; the other birds had been frightened away; consequently, I had the fish and the field to myself. I prepared at once to make a careful examination for possible parasites and other guests that might have been harbored on its skin.

The fish was intact, except for the eyes, which had been picked out, I suspected, by the crows. Indeed, I had once previously actually seen them do this very thing in the case of some clumsily swimming rays imprisoned between tides in the shallow waters of the pools. In the present instance, however, this atrocity was mitigated by the fact that the angler had already been quite dead.

That it had not been dead very long was apparent from its condition. But how it had met its end, how it had strayed from its native haunts on the floor of the Atlantic to be cast up on the sands of this sequestered spot, were problems hopeless of any solution. The sea has many of these . . .

II

What possible interest can one have in a dead fish? Well, of the entire number who chance to peruse these lines, there will probably be but one in whose mind this question will arise. Yet, for the sake of this single reader, I will explain that to the naturalist, a find of this sort is fraught with the thrill of a book of adventure. He reads in the sundry lines of the fins and tail, a romance of the ages. The very color tells him a story stranger than ever was found in fiction. With lens in hand, an excursion over its surface not rarely brings him to meet with peculiar, unusual, unknown forms—inhabitants of that normally invisible world in which many familiar portions of its teeming population are wont to reveal themselves in strange and striking aspects . . . But for sheer excitement he directs his deductive talents elsewhere—to him, the surface affords mere gleanings; it is in the digestive tract that the real harvest is to be reaped. I discovered, however, that I was without even a pocket-knife. In my haste to satisfy my curiosity, I had neglected to equip myself with such essentials. Therefore, there was but one recourse—to transport the carcass home, not exactly a light task, for I judge that its weight was not much less than my own. Nor was it a task attended without a certain inconvenience.

With such handling as I was obliged to use in stowing the limp and burdensome cargo, it began to belch what was apparently a part of its last meal. Several foot-long fishes, strange to me, and as yet unaffected by digestive action, were spewed along the sands; causing me to retrace my steps so that this odd collection could be secured intact. Notwithstanding, it was well within an hour that the dead angler was laid out supine on the dissecting table of my laboratory.

And here, in this seclusion, unhampered—unobserved by the chance passer-by or idly curious—I could proceed scientifically, uninterruptedly, and at my leisure, to the work of examination: a pursuit not always easily practicable in the open.

My workroom. A word or two regarding this retreat will not be out of place. What testimony it can bear of the strange and wonder-revealing inquests held within its walls! . . . Yet it is to the study of the living organism and not that of the dead that its use is unqualifiedly dedicated. Postmortem operations, it is true, often have been here performed; but, as in the instance now engaging our attention, they merely have been a means in a method of inquiry, and not an end.

Further witness, also, it can bear to the innumerable cloistered hours I have spent—alone, indeed, yet not lonely—in its plain but pleasing precincts, watching with sheer rapture some creature of my tanks as it exhibited certain unsuspected traits of habit or behavior; or, it may be, held with breathless awe at the microscope, glimpsing phases in the development of spore or egg or larva, phases which seemingly had been to me a deep forbidden secret. The truth is, the many long, though happy, vigils here maintained, have endeared it to me forever.

But what would the associations of this homely room hold for me without its heterogeneous furnishings, many of which are homelier still! The equipment is quite democratic, if I may so express myself. Here the plebeian broken half-bottle serving as a tank, with its colony of attached hydroids, just as it was found in the shore waters, is on equal terms—in interest, at least—with its larger, rectangular, imported plate-glass shelf-companion. Likewise, on the long work-bench before the row of large windows flooded with light on sunny days, finger-bowls, soup tureens, and other household china do duty in the cause of research as well as the most expensive of modern aquaria—and as efficiently.

Within arm's length of where I sit writing these lines (for this room, besides being a laboratory of natural science, serves as a writing chamber, study, and studio), in keeping with the general disparity, stands a plain pine table, a trifle wobbly now, and scored from long use. Like Fabre and his famous writing-table, I have a deep attachment for it. It was my first love. It was the very first piece of laboratory furniture that I acquired when I determined on my present career. But there is no need to go into that here. Elsewhere I shall have occasion to say something regarding those factors that had to do with the early shaping of this career. The faithful old table is now retired to a corner of the room, where it supports with what dignity it still retains a various assemblage of dead tests, crab molts, and desiccated seaweeds.

To speak of my favorite microscope, however, without some mention of its relation to me and my life's work, is to speak of it not at all. For it was due to the acquisition of this particular instrument, and all that that acquisition entailed, that I was privileged to become a fisher of facts—not always an expert one, perhaps, as sometimes these facts are extremely elusive. But always the sport is fascinating. No matter how insignificant the haul may be, it has elements of rare beauty. Not seldom is it that a vision of Truth is caught in the magic net of Science, as starlight is caught on the shuddering crests of a breeze-tossed sea, its reflection quickly fading into the Night of the Unknowable—leaving merely a memory, only a haunting recollection of that fleeting glimpse of a loveliness indescribable . . .

I see it now, as I saw it years ago on a winter night in a Chicago pawnshop window, its bright brass flashing under the cold gleam of an electric arc outside, catching my attention as I passed. I paused and appraised with understanding eye its every detail. Never had I possessed a microscope; never had I even looked into one of more than a very moderate power—and this occasion was in my childhood school-days. But I was not ignorant of the theory and construction and use of the microscope. My passion at that time for natural science as it had been revealed under the simple pocket magnifier (the sole optical accessory I then owned, for reasons presently to be divulged) had led me to absorb a large and various technical literature. The subject of lenses was especially attractive; and, always in the hopeful expectation that affluence would some day permit the possession of that last word in magnifying instruments, I read with religious fervor every work in the list in the public library.

It was late. The pawnshop was in darkness except for a light casting its dim rays over a huge vault-like safe in the rear. In the glare of the street lamp, however, I was enabled to note that the instrument was furnished with two objective lenses and an eyepiece which permitted magnifications ranging from 100 to 450 in power.

I do not know how long I stood fascinated, admiring its mechanical perfection; but I do know that I eventually became dimly conscious that some one was behind me and also evidently had interested himself in the contents of the show-window.

Clark Street at that hour was virtually deserted. A passing policeman, some minutes before, had been the only pedestrian who impinged himself upon my subconsciousness. Soon, however, I became vaguely aware that some one was behind me and that it was not the window but I that was engaging this person's attention. Becoming uneasy, I turned. It was the policeman. He said nothing; he merely glared. His glare, none the less, was more expressive than words. And I was impelled to leave forthwith, which I did without a murmur at what I indignantly regarded as an unjust suspicion.

It was on the following day that I found myself engaged in the preliminaries which were to place in my possession that tool which more than any other is essential to the naturalist's workshop.

"How much do you want for it?" I asked the pawnbroker, with a forced nonchalance, meanwhile working the rack and pinion focusing adjustment; trying by both means to hide my eagerness, and to impress him by my feigned familiarity with the fact that here was a knowing young man, one who understands what he is buying and who cannot be fooled in the matter of price.

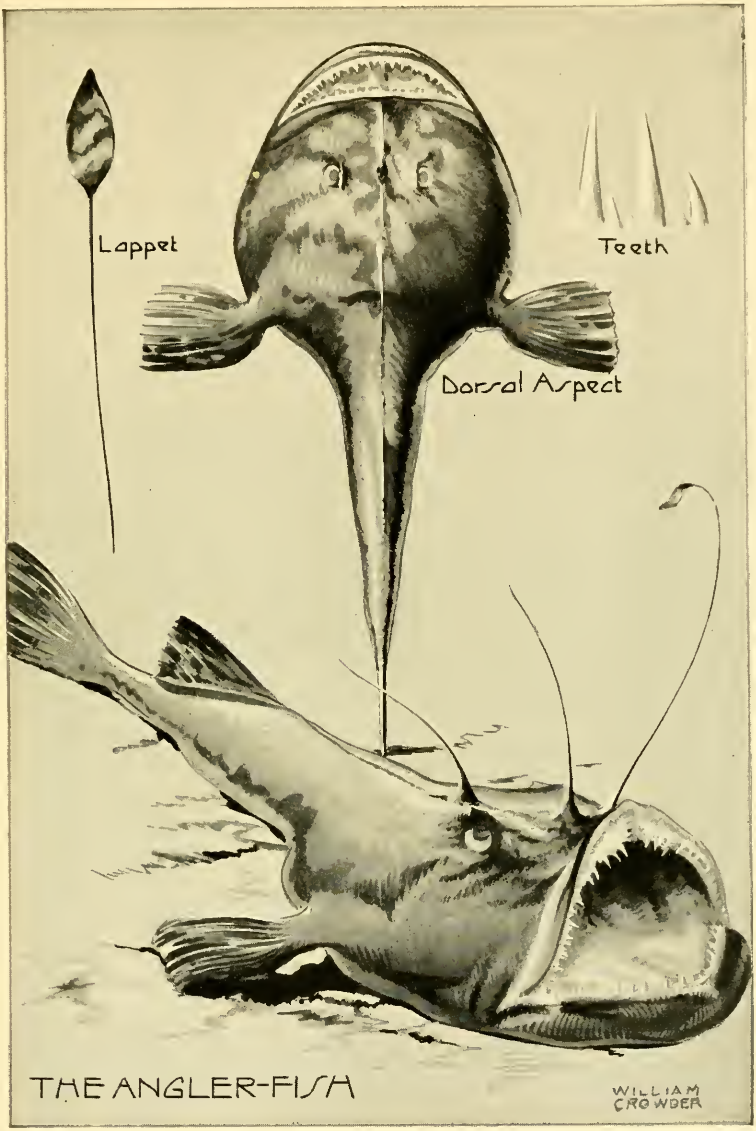
But the pawnbroker was not impressed. Indeed, I soon discovered something: he had but one price for his wares. He was tall, dark, intelligent; when he spoke it was obvious that he was a person of considerable refinement and culture. Yet the price of thirty-five dollars, absurdly low even for a second-hand instrument, was much more than I was able to pay. I disconsolately left the place.

Almost daily thereafter I stopped at the window to bestow a look of longing upon this new-found love of mine. I had, in truth, almost abandoned hope of ownership. But this did not prevent my yearning glances and imaginary seances poring through its eyepiece at wonders I knew existed but which I had never seen.

Nor did it prevent something more practical on my part: the preparing of mounted objects for the day when I might own either this microscope or its counterpart. One could never tell—better days might break at any time.

Thus also, incidentally, came about my apprenticeship to the delicate art of making mounted slides. I still have these slides. Occasionally I bring them to light to astound my growing sons: for I am secretly proud of them despite the fact that they were made mostly of window glass. The cover-glasses, of course, were purchased.

On these occasions, too, I indulge in a revel of


Lappet
Teeth
Dorsal Aspect
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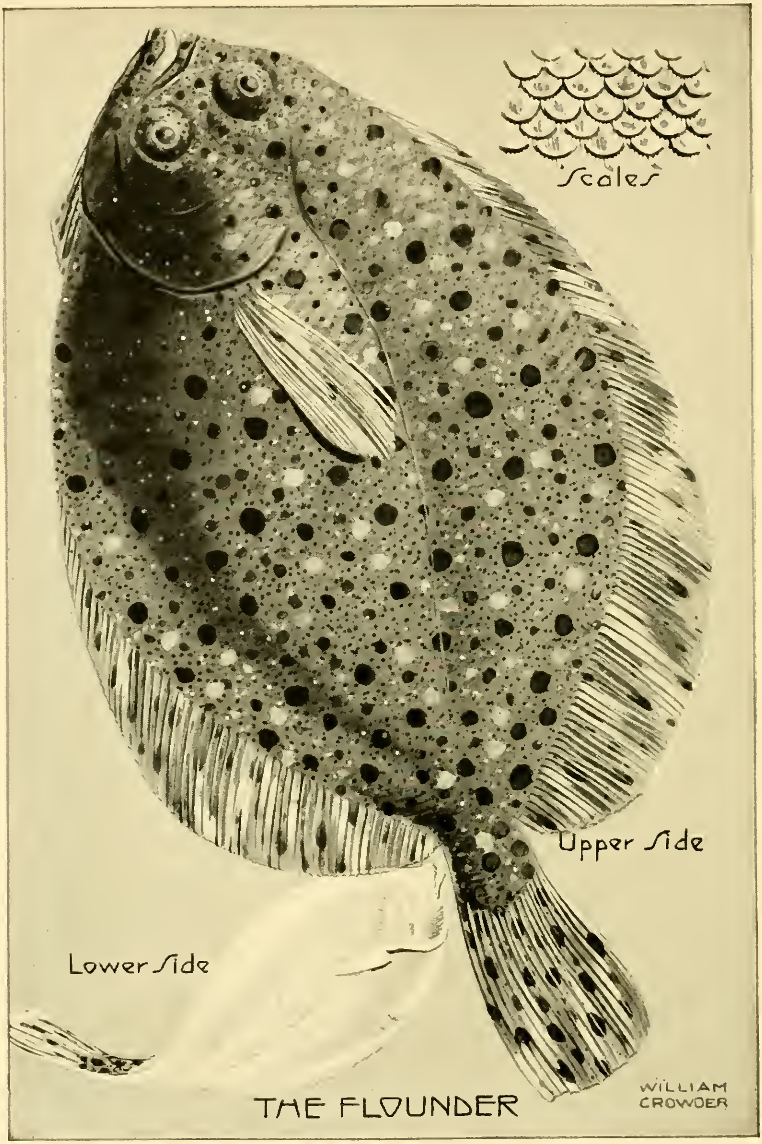
THE ANGLER-FISH


Scales
Upper Side
Lower Side
WILLIAM CROWDER

THE FLOUNDER

reminiscence: Here, embalmed in balsam, are pollens from my indoor plants, molds and fungus spores, mites and other minute insects, and many familiar but microscopically beautiful objects such as fish scales, and moth wings, and certain seeds.

Well, a better day did break. I found myself in possession of twenty extra dollars; enough at least to make a deposit on the microscope and insure its being mine.

It was, however, a full month after my first attempt at bargaining that I again entered the pawnshop; this time to claim the microscope as my very own. Once again I requested to see the instrument. I was privileged to examine it at my leisure, for at this conjuncture another customer entered to engage the dealer's attention.

Now came the moment I had been awaiting. Adjusting the mirror of the microscope, I pulled from my pocket the box of slides that had been so painstakingly prepared.

Wonder of wonders! Pictures and even the printed word had made me fairly acquainted with the magnified appearance of my subjects. But I was totally unprepared for the revelation of that beauty of form and color which was now in review. Slide after slide passed under the lens, each marvelous, magnificent, ravishing . . .

"Won't you step this way—the light is better . . ." It was the pawnbroker's voice. In my absorption, I had not noticed that we were once more alone. He led, while I carried the microscope into his private cubicle.

"Are you a microscopist?" he continued when the instrument was deposited upon his desk.

"After a fashion," I said, trying to be as noncommittal as possible. Veriest amateur though I was, I had no intention of divulging that fact. He observed my actions with interest as I completed the adjustments of the microscope. When I reopened my box of slides, however, I thought that I saw him start. But I was not quite sure. He picked one up and holding it to the light examined it curiously.

There was no need to dissemble further. The unprofessional slides were sufficient evidence of my status. Even the dullest wit could detect that. And he was obviously no dullard. With a skill at which I could only pretend, he deftly slipped the slide under the stage clips and centered and focused the object rapidly and accurately.

"Hm—not bad, not bad at all. Maybe a trifle over-stained, but——"

And so the conversation started. He went through my entire set of slides, making running comments as some feature struck him, comments always kindly critical. Then the talk turned from the topic of practice to that of theory. Here, however, I was surprised to learn that my attainments equaled his. I discussed on even terms the principles by which the formulas of lenses were computed. I spoke not inferiorly of the physics of diffraction, the reasons why different kinds of glass were used in the construction of lenses, while he listened with grave attention—and, I believe, with deep interest. Obviously, this was information of a sort which he had not expected to find in one otherwise so inexpert; and I, in youthful vainglory took pride in displaying it. For more than an hour we were thus occupied, with only an occasional interruption by the entry of customers.

Then it was that I came to the point.

"I should like to buy this instrument."

"How much is it worth to you?"

"Well," ventured I, at the same time feeling in my pocket for the money I was to offer as a deposit, "I have twenty dollars here——"

"It is yours."

And a few moments later, I was wending my way homeward in delirious joy, carrying with me the precious parcel.

It was thus that I came into ownership of that instrument which more than any other acquisition determined my future course. For with its possession I was forthwith passionately engaged in the pastime of peering into invisible worlds and prying into heretofore secret affairs of Nature—a pursuit which ever since has been at once the diversion and the serious business of my life. True it is, the range and the power of my instrument were, as microscopes go, not of the greatest; but for my amateurish enterprise it was a splendid foundation. Without its use I could not have perfected that exquisite technique which later enabled me suddenly and of necessity to employ with precision that last word in optical mechanics—the oil-immersion lens.

Since that eventful day, I never again saw my pawnbroker benefactor—for benefactor he was in every sense of the word. Indeed, I have always entertained more than a suspicion that his was an acute as well as a sympathetic understanding. To him, therefore, I owe a debt of gratitude. His generosity was well-timed, if not—as some may insist—well-directed, for as subsequent events proved, I would have been for an overlong period at desperate straits to make up the balance of my intended deposit.

Years later, when one of the most celebrated murder trials in Chicago was engrossing the attention of the populace, it was to me, as well as to the rest of the world, of absorbing interest. But its interest, in my case, had a unique aspect. The most important clue by which the convicted murderers were traced was obtained through the formula of a broken spectacle lens belonging to one of the murderers. And I recalled how in the far-away days, in a cubicle of a pawnshop, I had among other points in an animated conversation touched upon principles of lens formulas and upon forensics and its relation to things optical . . . And one of those most vitally interested persons in that famous case was the victim's sorrowing father—my pawnbroker.

III

But let us not forget our angler-fish. Behold this creature now approximate on its back on the dissecting table, just beneath the skylight, in the center of the laboratory. Near at hand on a small stand is a tray neatly arranged by my able assistant and containing an assortment of forceps, scissors, knives, mounted needles, and other instruments for the purpose at hand.

My assistant, that is to say, my wife—whose dexterity and skill at this business of refined carving have always been my admiration if not despair—begins by slitting open the belly, while I stand ready with a large hand glass and forceps, awaiting whatever may turn up. At once there is exposed the large stomach of the animal, distended with food, and seeming at first glance almost to fill the entire abdominal cavity. Indeed, so gorged is this organ that the outlines of certain of its contents can readily be traced in the contours of the surface; thus making it easy to believe the books, wherein it is stated that "not rarely fishes have been taken out quite as large and heavy as their destroyer."

A puncture is made in the stomach, and then a pair of strong sharp scissors brought into play soon reveals the nature of the angler's last meal. This repast, it would seem, consists entirely of a single species of fish, such as had previously escaped from its maw, until by removing the contents to the extent of a dish-pan-full, one fish, lodged well up in the gullet, is brought to view that is totally dissimilar.

Here, in fact, is a find as potentially promising as was its larger captor. It is a flat-fish, or flounder, but of a type seldom seen near the shore; it inhabits only those darker depths where the oozy bottom on which it rests invests it with a somber guise and characteristic markings of its own. And it, too, like the angler-fish, is predatory. We must investigate.

It is axiomatic that to live one must eat. But in the salt-water world, to live one must continually be on the alert to keep from being eaten. Excepting perhaps the starfishes, certain sponges, and a very few other low forms, the great majority of marine animals are constantly waging a defensive warfare. Hardly a creature is without some enemy that seeks its life in order to sustain itself. Nor is it entirely a matter of one kind preying upon another. With a great part of the population, cannibalism would seem almost to be not the exception, but rather the rule. And nowhere else does the remorseless aspect of Nature present itself more plainly. Judged from our human viewpoint, cruelty is its commonest feature. Few of the higher creatures of the land there are, that do not kill outright or render unconscious the prey which they are about to devour. Even the predatory insects are usually equipped with some benumbing or paralyzing device wherewith their victims are brought to an easy or painless death. Such methods are restricted to only a few that live in the sea. A crab will seize its smaller neighbor—not seldom its own species—and with utter nonchalance (if such psychic attribute may be applied to a crab) deliberately pluck off the legs and other appendages and devour the other piecemeal. Snails bore into barnacles and other immobile forms and literally hack the helpless prisoners into fragments. Aside from the jellyfish and its kindred, which at least partially paralyze their prey, and their more agile fellow-citizens, the backboned fishes and the cephalopods, which destroy at once or engulf their victims whole, not many killers, indeed, are given to even the rudest sort of mercy.

Here it would seem that there is food for thought. But I refrain from ruminating over this flavorless fodder. Considerable drool is already extant regarding the ruthlessness of Nature's ways; and much of this is false philosophy, pure and unadulterated drip . . . The larger preying on the smaller, the stronger on the weaker . . . Shocking; yet typical of the lower brute . . . But is Man any better? After all, this is simply a problem of food, and in solving this problem, we have in no way proved ourselves to be superior to them. It is true, we no longer eat one another; but we have not ceased from resorting to butchering one another—and we butcher with artificial refinements of cruelty and torture such as are nowhere else found among the creatures of Nature . . .

The flounder is laid aside for later examination, and with my wife's continued help, I now give attention to the remainder of the angler's intestinal tract. Our visceral pilgrimage, however, yields little of interest; the process of digestion has worked so well that not only the identity but (superficially, at least) the very nature of its food is not readily recognized. Also, our fish seems singularly free of the usual guests that help partake of its food: we find not even a parasite. And that is all that the angler seems competent to give. The net result of the morning's labor is a heap of unpromising and unknown but ordinary-looking fishes—a kind of herring—numbering nearly forty; and one fifteen-inch flat-fish, a bottom dweller, and therefore a likely find, but as yet holding only a hint of possibilities.

Before proceeding further with these new-found fishes, let us take another look at the angler. It will be our last. Unquestionably, this is the most hideous vertebrate in the sea. Yet, notwithstanding what meets the eye, it is peculiarly worthy of our admiration and regard, for its very ugliness bespeaks one of Nature's most beautiful examples of perfect adaptation to environment. That environment obviously is the mud and silt of the ocean floor. Its color alone—a deep slaty-black—betrays its liking for the depths; but it is another and quite singular feature that reveals its actual mode of life; a life for the most part passed groveling—indeed, *crawling* may be the better word—on the bottom. The pectoral, or paired, fins are fleshy affairs, well muscled and so jointed as to perform the functions of feet. Nor is this all. It is patent that *Lophius* is an indifferent swimmer. How, then, does it manage to overcome its prey which as a rule is more active and much fleeter by far?

Of course, although the angler is not an abyssal animal, no one has ever penetrated those depths in which it lives, to observe its ways, nevertheless, a good picture of certain of its methods may be formed from deduction. Mention has already been made of the filamentous fin which serves as a feeler, if not actually as a lure. This latter function is not an improbability, as in certain deep-sea relatives of this creature the terminal lappet is supplanted by a phosphorescent organ. Now, too, where our *Lophius* lives, it is deep in gloom, if not densely dark. Here resting on the bottom, of which, by reason of its color, it seems to form an indistinguishable part, and with its large lugubrious eyes looking upward, trying vainly to pierce the blackness of the perpetual night, it projects its peculiar fin slightly forward—the verisimilitude of a rising frond of seaweed—and patiently awaits its prey. Soon or late, a single one or an entire school of swimmers may chance to pass. Then upon the merest contact with this weed-like fin, through accident or design, there is set into motion a veritable spring trap. The huge jaws beneath instantly open. With the aid of its powerful pectorals the angler-fish fairly leaps and suddenly engulfs the unfortunate victim—or victims, as the case may be . . .

It was undoubtedly in this manner that the fishes I took from *Lophius* were caught. That this capture was made shortly before the captor's death, I have previously had occasion to remark; but now, further examination reveals what was not apparent before. I find that not only was this capture made almost at the instant of the angler's death, but it was also made not many moments before I came upon the carcass at the beach. The very condition in which both the creature and its stomach contents were found, was ample testimony of their freshness. It is, however, quite another matter that leads me to determine the truth of this assumption; and this matter takes us at once to the consideration of that strange grotesquery of the sea, to which allusion was made at the beginning of this chapter.

IV

It is night. I am now alone, sitting at the long work-bench that runs the length of my laboratory. The room is in half-darkness, except for a brilliant spot of light cast upon the bench by the shaded bulb at my elbow. A faint mist hovers within the luminous cone—the last remaining traces of tobacco smoke from a pipe long since gone out. The laboratory has been cleared of the organic litter of the morning; not a trace of the once-seeming shamble now shows, unless it may be in the notes and the drawings I made of it, and the Thing here just before me, the corpse standing stark on my bench.

As I had suspected, when I turned to the herring-like fishes, the result was negative at best; nothing of note was found in their bellies. In fact, they were nearly empty when meeting their end; indicating that they were pressed by hunger and were searching the bottom for food. With regard to the flounder, however, my larger hopes were realized far fuller even than I had dared to anticipate. When the flat-fish was seized, it was in the act of feeding; it had not even had time to swallow its food, for its mouth and throat were crammed with hydroids; and it was in this mass of tangled material that I found, still alive but barely moving, a pycnogonid, or sea-spider, the pale and colorless creature with whom I now hold solitary vigil far into the small hours of the night.

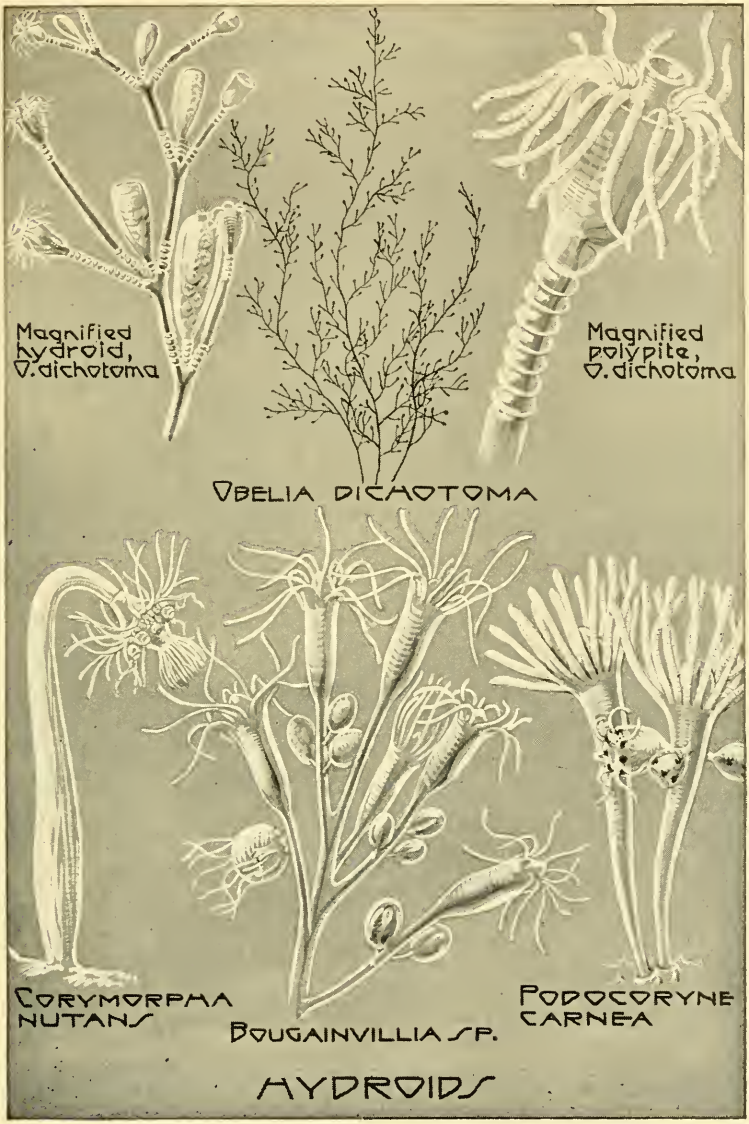
That this animal was yet living is not so extraordinary as at first sight it may appear, and the reason for this tenacious vitality will quickly become clear, when presently we come to make a close examination of its structure; but the point here I wish to press is that it was due to the fact that it was not dead when found, that proof is established of the nearly simultaneous and positively recent finish of the flat-fish and the angler. Had my finding of the latter, and the consequent recovery of the sea-spider, been long delayed, this new-comer, too, would have perished; not from suffocation, but from the poisons evolved in the angler's stomach or from actual disintegration by the free digestive juices. Yet even this experience was more than its delicate nature could long survive. In less than two hours after its removal to a jar of clean cool sea-water, it released its hold on the hydroids and slowly sank to the bottom to die . . . And soon after expired a numerous progeny; it had been literally covered with young.

This event brought forth cries of dismay from the members of my family, who were gathered closely around, watching with hushed wonder the comical gravity of the slow-motion antics performed by the queer little stranger from out of the depths. To me it was also a tragedy. I had hoped to rear the little spiders to maturity—an undertaking fraught with rare interest; besides, it would fill some gaps in a knowledge of which natural science seems singularly barren. But insight into the pycnogonid's ways has not altogether been denied me; such as it is, I shall endeavor to share with the reader.

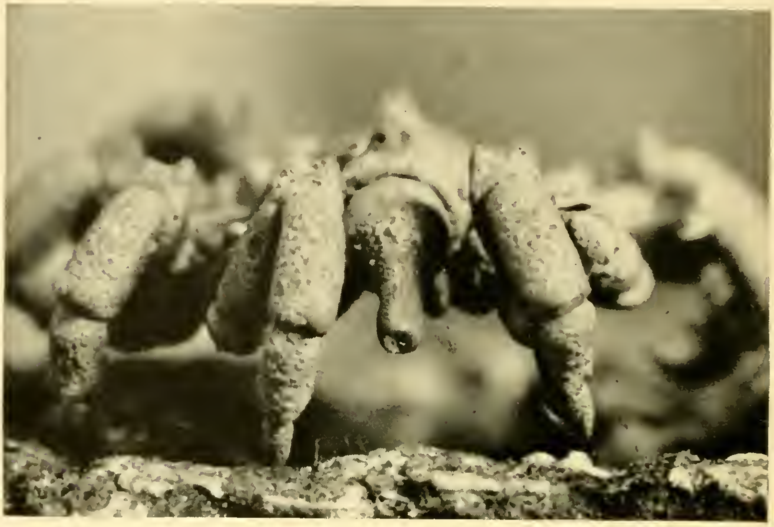
Pycnogonum littoralis. A big name for so tiny a creature! If the degree of popular interest in an animal is governed by size, then it must be conceded that the sea-spider has little to offer. Actually it is smaller in expanse than a ten-cent piece. Yet how immeasurably large it looms in the understanding imagination! But this aspect will occupy us later; first let us familiarize ourselves with its physical attributes, among which are probably the most outstanding eccentricities of the animal kingdom.

Under the hand-lens my sea-spider reveals itself at once, superficially at least, as being a distinctly spider-like creature; that is to say, it has eight long legs radiating from what, for the want of a better term, I shall call its body. But here the resemblance to the spiders ends. In every other detail, it differs as much from the true arachnid as does the bird from the bat. I am not unmindful that by some naturalists it has been classed as an arachnid. The truth is, however, that it cannot with certainty be identified with any other known group of animals. There are upward of two hundred species comprised in the Pycnogonida, and in not a single one is there found a distinctive affinity with the typical spiders. It stands alone, unique.

But let that pass. It holds something more important for us than systematic distinctions. About the first thing that strikes us is the fact that this creature is without a head, so to speak, and it is all but utterly devoid of an abdomen; what exists of its body consists almost entirely of a thorax —and there is even not much of this. In short, the sea-spider is virtually all legs.


Magnified hydroid, O. dichotoma
OBELIA DICHOTOMA
Magnified polypite, O. dichotoma
CORYMORPHA NUTANS
BOUGAINVILLIA SP.
PODOCORYNE CARNEA

HYDROIDS



CLOSE-UP OF A SEA SPIDER
Enlarged ten times

COLLECTING AT LOW TIDE

Strictly speaking, the body is composed of a cephalothorax and three thoracic segments. The cephalothorax, or forward end, viewed from above, bears a cone-like suctorial proboscis, four simple eyes on the top, and the first pair of walking legs. The remaining three segments each bears a pair of walking legs, also; but the third, or last, segment, in addition to the legs, carries at its end a little stump, an aborted belly, a rudimentary abdomen which is a nonentity literally and physiologically. The legs consist of nine stout articulated segments bearing at the terminal tip a sharp hook. Each of the four divisions of the body is surmounted by a tiny tubercle; it is on the tubercle of the head-region that the eyes are placed.

Turning the pycnogonid over on its back, I find another pair of legs under the cephalothorax, diminutive in size, but like the larger walking legs in all essential respects. Small as they are, I realize that this is only a comparative distinction when the sexes are considered, and did I not know from the fact of its attending young, merely the evident largeness of these lesser appendages would tell me at once that my creature is a male.

Let me explain. The female differs but little externally from the male; this trifling difference, however, lies partly in the more conspicuous generative orifices and to some extent in the appearance of the fourth joint of the legs, which often is swollen; but chiefly it lies in the diminutive so-called ovigerous legs under the body which are usually not so well developed as those of the male.

This completes the picture of the outside—if indeed an adequate representation in words ever can be possible of such a monstrous mite. The internal structure is even more singular. Unlike all other animals, wherein the body is distinguished apart from the appendages as being the seat of the vital organs, the sea-spider has all its principal organs concentrated in the appendages. The alimentary canal, although beginning at the proboscis and ending at the opisthosoma (hind-body), is lodged largely in the limbs, sending long sac-like processes into these appendages. Also, on each side are the generative glands, sending their prolongations into the appendages where the opening duct is to be found on the second segment of the forward pairs. No gills or other organs of respiration are present: the animal absorbs by means of its integument the oxygen necessary for its blood.

It breathes through its skin. And this, by the way, gives us to understand why it was that our pycnogonid did not suffer from asphyxiation within the walls of its double prison.

In keeping with the remarkable structure of this strange beast, is the equally remarkable strangeness of its ways. It is the male, and not the female, who incubates and mothers the young. When the eggs are laid by the female, the male gathers them with his ovigerous legs and deposits them in the sac-like pockets at their bases and thus holds them until they are hatched. The members of the brood when born are unlike the parents in that the segments of the body are not so pronounced or are actually wanting; but after a few days, possibly weeks, during which period they may be seen clambering over the fathers, several moltings of their skin takes place. With each successive coat they acquire a more adult-like character; then finally they shift for themselves.

Such, in brief, is the description and history of the sea-spider; such is the summary of my observations, which agrees with that of the meager literature pertaining to these animals; such, it would seem, is all that is vouchsafed for Man to know—

for few creatures of the sea are more difficult to maintain and keep alive, more difficult of study.

And yet I am far from satisfied . . . As I sit here in the silence of the night, solitary, pondering over the remains of this pycnogonid parent and his brood, there is a certain aspect to this wholesale dying business which continually presents itself from behind the shadowy curtain of my puzzled thoughts. The death of the large individual I can at least account for, if not understand. An injury or some cause which had to do with its capture and confinement could have been a probable reason for its fatality; but surely these reasons cannot be urged with equal force concerning the successive and rapid dying-off of plainly unharmed young. This remains a mystery, intriguing, tantalizing, until finally and with startling suddenness the truth-revealing realization flashes full across my consciousness . . . Bit by bit, a half-forgotten memory now returns, and I recall how on a former occasion, early in my contacts with the sea, I chanced upon a spray of floating seaweed. Among its gauzy branches was a minute creature covered with ghostly parasites—each atom clinging tightly, its head almost buried in its host. That creature, although I did not know it then, was a sea-spider—but of another kind—and the fancied parasites were its tender young. That beginning, and later similar observations in the light of a larger understanding, now overwhelm me with a deep conviction—the death of my little sea-spiders was caused not alone by their being unable to shift for themselves, but also by hunger. For with the death of the parent the food source died too . . .

Bear in mind, the young are carried by the male until they have passed through several molts. In the meantime they grow. To gain growth requires food. Like their elders, they are sucking animals, subsisting only on liquid nourishment obtained only by extracting the juices from some other animal—or, possibly, plant. As they do not for a moment leave the fathers during this early period, they of sheer necessity are obliged to find food somehow; consequently they turn to him; applying their proboscides they feed directly through his skin. Thus, by this most extraordinary of fathers, they are not merely nurtured, they are actually nursed!

V

And yet it is seriously asserted that there is little of innate beauty—little of human interest—in the lives of the lower animals of the sea . . .

Well, possibly it is because it is partly as an artist that I appraise these lowly creatures as something more than objects fit merely to classify, dissect, or subject to experimental tortures . . . and forget; yet such sensitiveness to beauty as may be mine does not distort the perspective of the naturalist in me. The truth is, in all my relations with these humble creatures, I am the naturalist first and the artist afterward; notwithstanding, I do not on that account feel that I should be insensible to the thrill of beauty whether it be either in the abstract or the concrete: whether it be in a mode of living or in form or color. After all, Science and Art are similar. They both, so to speak, are minor deities subserving one greater god, Truth. And for their adoration the devotee need burn no different incense on the altar of one than that which is offered on the altar of the other. Nevertheless, in my contacts with that wonder-world, there come tremendous moments that are neither of Science nor of Art—these are moments of the Infinite. Such moments are mine when I look upon some strange aspect of biological beauty which is associated with a physiological horror, such as is found in the example of the sea-spider. Then it is that I forget the lens and the forceps and the brush. No longer am I a cold and critical investigator, calmly seeking naught but facts and pictures; the heart beats faster, a glow begins to quicken, and I become as one with even this most unprepossessing of Nature's progeny; for I know that it, too, is warm and human. I see it, not as a seeming excrescence on the tree of life, invoking dread and loathing, but as a perfect response to an environment to which it has adapted itself with even better grace, perhaps, than have I to mine. And I know that although our separate branches are remotely apart, the vitalizing sap is identical in us both—we are the same in essence, we are kindred . . . Even more—who can say whether, in the destiny of life on this planet—or, if one will have it so, on some faded star still cooling in the mightiest reach of the cosmos—the ganglion will have been less mighty, less important than the brain, ere the final phase of organic evolution comes to a close?

CHAPTER TWO

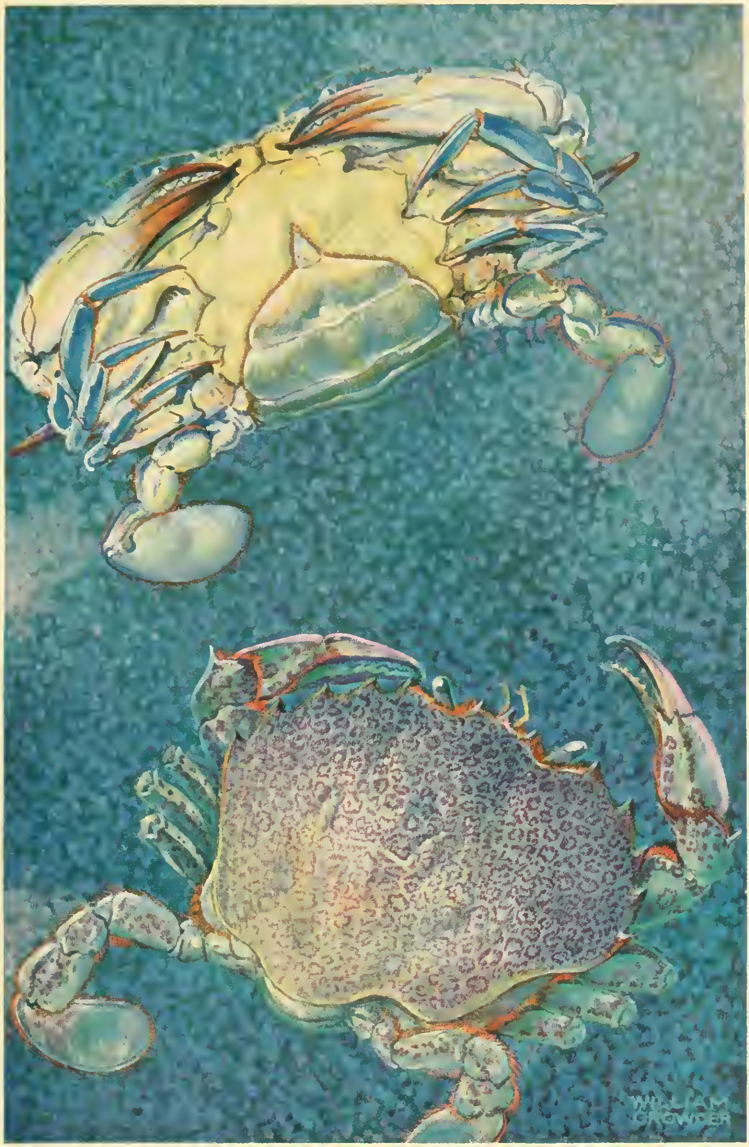
A Problem in Deduction

I

THIS will be a chapter of precedents. I purpose to reveal a history of the blunders and disappointments rather than the easy successes attending certain of my own studies in connection with the sea. I shall describe how, in the pursuit of Nature's elusive secrets, various pitfalls beset the trail, retarding the naturalist's progress often for years. I intend to detail not the romantic way in which the staggering intellect of a laboratory recluse is popularly believed to rise superior to those obstacles, but the means and methods in investigation as they are actually applied. I shall show sufficient for the intending student to enable him to profit thereby; to the world at large, I shall show a side of this brain-bursting business of biological lore-hunting seldom bruited by the bearded professors; in short,

SWIMMING-CRABS

Callinectes: the blue- or edible-crab (upper)
Ovalipes: the spotted- or lady-crab (lower)


WILLIAM CROWDER

SWIMMING-CRABS

I shall show exactly how the marine naturalist works.

We are all of us aware that the chief stock in trade of the magician is his ability to keep us mystified as to the method in which he performs his tricks. When once we become aware of how he works his seeming wonders, our interest and respect are at an end. Thus it would seem to be in the minds of a lingering few so-called men of science concerning their trade. I say "a lingering few" because there are still some left whose mind and manner are of the Middle Ages; they are fearful of familiarity with their way of working, lest they lose the prestige of their craft. Verily there was a time when *all* scientists actually encouraged the public in the belief that research work was one of mystery and legerdemain. It was in this manner that originally came into being the modern symbols and abbreviations used in medicine and pharmacy and in some branches of biology and astronomy. The odd codes of the alchemists, no less than the use of Latin by the ancient leeches, were designed to keep from the ordinary man the secret of the real nature of their methods and of the composition of the remedies they prescribed. But the heritage of that time, fortunately, is fast fading. To-day, the esoteric aspect of science is regarded by most of mankind not as a sorcery, but as a vital part of our daily life: it is no longer looked upon as a recondite study, but as part of the cultural foundation on which rests the welfare of civilization.

So if, in telling a tale or two out of the school of my own experience, I hurt the sensibilities of some of the medieval-minded Magi, well . . . that is just too bad! The primary purpose of this book is to enable the reader at large to know the lower animals of the sea as I have learned to know them—to see them as beings friendly, familiar; and not regard them with awe or even dread because of his lack of understanding. Let us then, between friends, dispense with mystic frumpery; the marvels of their ways will ever remain as enchanting.

Every craftsman, whether he be a mender of shoes or a tracker of electronic orbits, has his "bench tricks," his short cuts and individual devices for facilitating the work at hand. Not seldom are the means and methods employed of an unconventional nature; that is, of a kind not usually suspected by the lay person as even remotely connected with the work. Therefore, on a collecting expedition I am now about to describe, it need occasion no surprise to learn that although my quest was for creatures almost microscopic in size, my equipment consisted not of fine-meshed muslin nets and glass containers or even powerful optical accessories, but merely a hand-lens, a wooden tub, and a garden rake.

A December sun gave out scant comfort when with my Faithful Assistant at the wheel of the *Hippocampus* I ran the engine at its fullest speed as we headed out from the cove straight into a freezing, half-gale sea. As we passed close to the breakwater at the harbor entrance, a lone fisherman perched on one of its massive stones stared at us and shook his head, but said nothing; evidently reserving his opinion of two foolhardy irresponsibles who would venture out into the Sound in such weather aboard a tiny catboat.

But we knew the *Hippocampus.* And in less than an hour we were anchored in the lee of a line of enormous glacial boulders reaching several hundred feet out into the water from a promontory on the Long Island shore.

Stowing the tub and the rake in the dinghy, I rowed alone to the nearest group of rocks, which now at the time of ebb tide exposed a solid drapery of dark-green seaweeds below the high-water mark.

Here indeed was a likely source, as the dense growth of fucoid plant-life, being the permanent home as well as the temporary shelter of innumerable small animals, usually affords a dependable supply to the collector. But it was not in the wave-washed wilderness above that I wished to hunt, it was in the groves beneath the surface. And it was to that end that I had brought along the rake. In the summer, even this implement would be unnecessary. Now, however, the temperature of the water as well as that of the air would be extreme torture if not almost certain death to the diver. As a matter of fact, it was with most decided difficulty that I was able to continue for long with the use of the rake; the wrenching loose of the underwater tangles obliging me at times to immerse my arms far past the elbows, and such work in an element that is below even the freezing point of fresh-water, soon ceases to be a labor of love—it becomes sheer self-martyrdom.

Nor was the factor of temperature the only consideration that made collecting arduous: I had to contend with an increasing sea, which, to begin with, was by no means calm. Though working my little boat around the least exposed side of the rocks, the great surges to the windward communicated themselves in a continuous series of risings and fallings, a sequence of liftings and lowerings of my craft, which eventually allowed opportunity to wield the rake only when at the bottom of the turbulent troughs.

Yet there were compensating distractions. How this same sunken garden, swaying in the frigid depths, would have appeared to any other observer, I cannot know. But to my mind, certainly, there was something singularly enchanting, something weirdly attractive in the primitive grace of its floating fronds. (For the seaweed Fucus, although firmly attached at the base, by reason of its large and considerable air pockets virtually floats at whatever depth it finds a footing.) In the slanting sunlight, the tough leathery character of the individual plants was lost and their deep olive tone was disguised, the skin reflecting the soft sparkle of a thousand vanishing tints—as mellow rays are reflected by the translucent fabric of fine silk. Still, the impression they wrought by their appearance was made not so much upon the retina as upon the brain—it was an impression not of seeing: rather it was one of feeling. There was produced within me that unutterable consciousness of hovering in ecstatic propinquity with an extramundane world, a world not cold or liquid, but warm and airy and where gravitation did not exist. And as some small sable-finned sea-horse remained poised for the moment, fanning the water before it was startled from its retreat, the illusion was still more deeply pronounced.

At last I was compelled to desist from collecting and I returned to the *Hippocampus;* the combination of wind and waves and cold would have made further efforts insufferable. It was not, however, without a fair harvest that we left. When we turned the prow homeward, the tub more than half full of seaweed was in the cabin so that our reaping would not be killed by the forming ice.

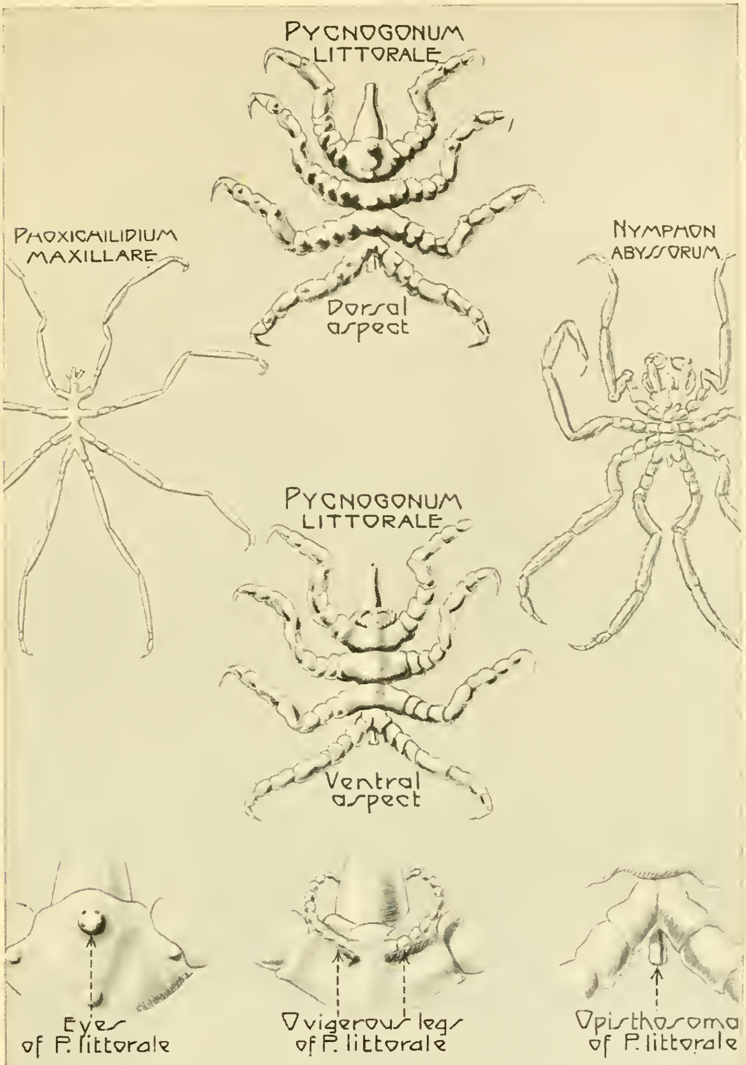
I have already remarked that when we left the harbor it was blowing a half-gale. But that was merely a zephyr compared with what we now had to combat. Indeed, much could be said about that return trip, about the fury of the blast—and this despite a clear sky—about the fearful cutting cold, about the yawings and near-founderings of the *Hippocampus;* but as this is not a tale of men (and women) who go down to the sea in ships, suffice it to relate that we reached the laboratory at last, safe yet not exactly sound: both the motor-boat and our persons were so freighted with ice and rime that we were objects of wonder to the populace, and of dismay to our children who greeted us almost in tears at the dock.

II

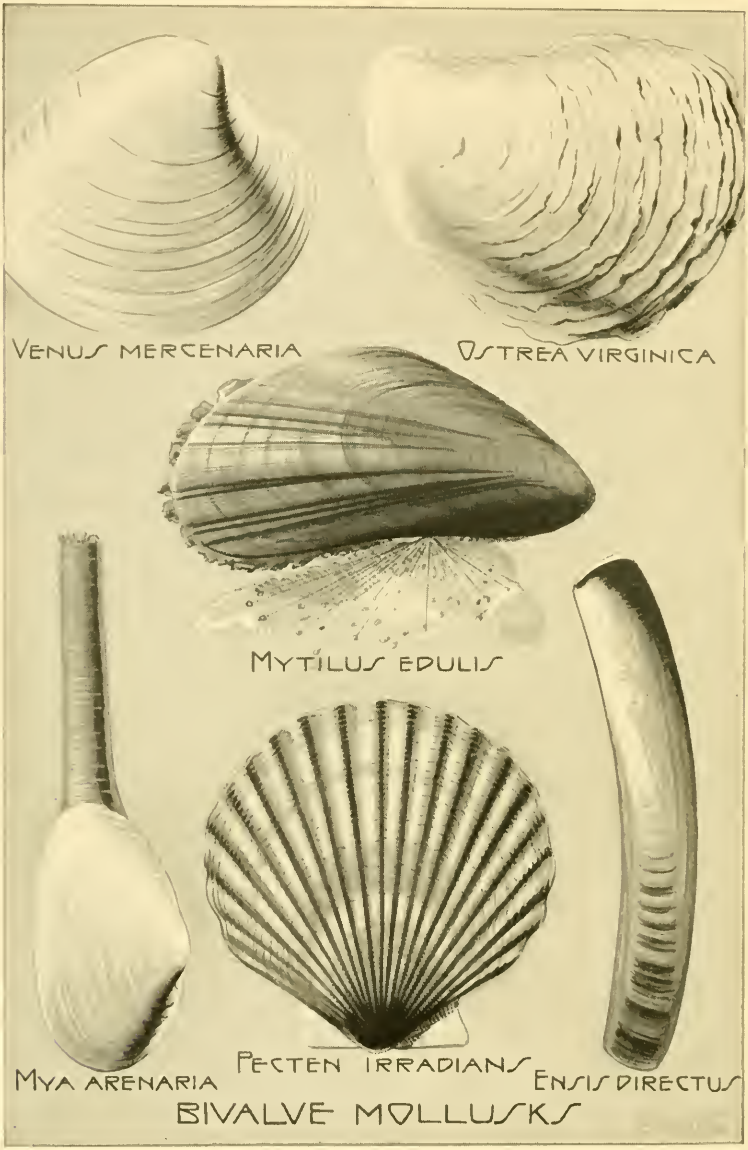
Of the minor disappointments attending the work of the naturalist, few occur more frequently perhaps than his failures in the finding of needed material for study. This statement may seem strangely inconsistent with my references to the teeming life of the sea; yet it is a common experience for the collector to set out with the definite purpose of securing but one type of subject and return without so much as even a clue to the whereabouts of his quest. The truth is, much of his most interesting finds are owing to the result of fortunate accidents rather than to that of design. To be sure, there is always prevailing an abundance of one or several forms of life, but not always precisely the type that is wanted for the purpose immediately at hand. So it is that the observer of Nature learns after long experience somewhat of philosophy if not much of the problem he has set upon to solve—he learns to take things as they come.

And so it was that I began my investigation of the habits of the serpent-star, an animal than which few creatures of the sea lead a life more simple; yet a creature and a life history whose very simplicity baffled my every attempt over a considerable period to gain an intimate acquaintance; and, I may add, it was then I began that series of blunders of which I have spoken, blunders into which I was betrayed by my believing everything I read in the books.

Indeed, my discovery of the serpent-star was the only worth-while result that attended the expedition on that cold and windy afternoon. When the tub of seaweed was examined in the laboratory, there was not a single *Caprella* to be found—for that is the name of the little amphipod whose acquisition was the primary object of our venture. *Caprella*, sometimes called the "skeleton-shrimp,"


PYCNOGONUM LITTORALE
Dorsal aspect
PHOXICHILIDIUM MAXILLARE
NYMPHON ABYSSORUM
PYCNOGONUM LITTORALE
Ventral aspect
Eyes of P. littorale
Ovigerous legs of P. littorale
Opisthosoma of P. littorale

SEA-SPIDERS


VENUS MERCENARIA
OSTREA VIRGINICA
MYTILUS EDULIS
MYA ARENARIA
PECTEN IRRADIANS
ENSIS DIRECTUS

BIVALVE MOLLUSKS

is among crustaceans perhaps second only to the sea-spider in eldritch anomalism of form. In another chapter I shall give ample space to this curious beast, so for the present it may be dismissed without further reference other than that my desire to obtain it was because of an inglorious and unscientific wish for material to furnish a winter night's diversion with a new low-power binocular I had just acquired. But the finding of the serpent-star overshadowed in importance, by far, my failure in the pursuit of *Caprellas;* for, notwithstanding my failure, skeleton-shrimps are nevertheless comparatively common, while serpent-stars, although not exactly rare, surely are the shyest as well as the most secretive creatures of the sea.

When I found it, the last batch of seaweed in the tub had been placed in a large photographic tray filled with water and was rapidly, but carefully, being scrutinized under the hand-lens . . . There it was—it was not yet full-grown, a penny would easily cover it—its five snake-like arms starting to squirm vigorously as my glass remained hovering over it. Presently it slipped around the weed and swam across the tray. In a trice I reached for a pair of light forceps and was after it. Seizing it by one of its arms, I attempted to lift it out of the water, but all I retained from this effort was the seized member—the rest of the animal detached itself and insinuated the disk and its remaining four appendages into a nook offered by a protecting mass of weeds. It was plain that if I wanted a serpent-star for observation, this piecemeal method of capture would never do; so, cautiously separating the plant in which it lodged, I lifted it with the tiny captive from the tray and placed them together in a small tank of clean sea-water without any other addition than some fronds of sea-lettuce to keep it fresh, and some gravel and comminuted shells on the bottom—the latter of which were for the purpose of supplying, by entering into solution, the necessary mineral substance for the animal's growing frame.

Here, indeed, was material for my new instrument. It would be more than a mere diversion: it would be a serious undertaking: I purposed then and there to pry, if possible, into every secret of its private life.

But, after all, how was this to be accomplished? Obviously, one specimen would give scant opportunity. Moreover, what little I knew of these creatures was that they did not thrive in captivity; therefore I could reasonably expect to have in no long time a dead animal as an added difficulty in the way of a beginning.

My plan was soon formed. I would do what was possible with the subject at hand, until the arrival of spring when serpent-stars would be found in greater abundance. Meanwhile, I would also consult the available literature of the subject to see what it had to offer.

III

Picture, if you can, a large room (16 x 20 feet, to be explicit) well lighted on two sides by a row of nine great windows; overhead is a skylight through which the warm afternoon sun is streaming, flooding a huge glass tank filled with salt-water and sea-lettuce with an emerald brilliance. A score or more of smaller tanks, of various kinds and sizes, are clustered close to the row of windows at one side, almost completely covering a long shelf-like work-bench that ranges the lower sills. These aquaria, too, like their larger counterpart, give out a greenish glow, casting a delicate glaucous hue over the other objects in the room, by reason of the seaweeds they contain. In a remote corner is a spacious table, obviously used for writing; for besides its burden of books and tobacco, it carries a litter of paper, each sheet being inscribed with numerous notes. Around and about this table, on the wall, as well as over a little typewriter-stand adjoining, similar sheets are thumb-tacked, proclaiming in bulletin-board fashion to whoever would trouble to read, sundry facts regarding one serpent-star *Amphipholis squamata;* while in another corner, near the light and close by some tiers of glass-enclosed shelves laden with reagents, instruments, and pickled corpses of various sea animals, stands a drawing-table. If the notations tacked around the writing-table should fail to indicate to the lay person what at this period is the absorbing passion of the occupant, such cannot be the case with the drawing-table. For pictures are a universal language; and here, newly painted in full color, are large representations of the serpent-star in different positions. Most convincing of all, however, is the actual presence of the serpent-stars themselves. By peering sharply through the glass sides of most of the smaller tanks, one can detect in each container two of these creatures hiding—

as well as the exigencies of their retreats allow—in the shadows or in the fold of a sheltering frond.

This, then, was my laboratory on a day in June, more than two years after the eventful expedition into the Sound. Two summers and three winters had elapsed since my determination was fixed to read the riddle of their existence. And on this day it seemed that I was at last within reading distance of that riddle . . .

What assistance I had derived from the literature was negative at best; and some of this help proved, so to speak, actually to be a hindrance. The books I had consulted—and none was more popular in this special field—were all agreed, down to the minutest detail, as to the ancient history of the serpent-stars, delineating with exactitude their line of descent and their relationship with the ancestral crinoids; but to facts of their present life history, there was barely more than a reference. Some writers, indeed, ventured to make much of the mystery surrounding the habits of these creatures. With this perplexing aspect, as presented by the books, I was confronted at the start; yet something I saw among their statements led me to take heart.

It seems that while the authors were in accord as to what happened millions of years past, they were somewhat disagreed as to what was taking place seemingly under their eyes. One confidently asserted that dead fishes and mollusks form their chief food, while another with equal certainty maintained that they live mostly on plants. From this I guessed that the truth lay somewhere between; and I set about to make that truth my first objective.

This initial step in the program was also one of expediency. If my lone serpent-star of the tub was to be studied as a living animal, it was necessary to learn how to feed it. But notwithstanding the tender solicitude with which its welfare was watched over, it died within twelve hours. The choicest variety of food ever set before an invertebrate was set before it—fish flakes, crab meat, small crustaceans, minced mollusks, and algal scrapings—yet it disdained them all. One thing I did learn from its brief span in my tank, however, was the fact that it was a creature of the night. During the daytime it remained secluded in the darkest crevices of the pebbled floor, inactive and scarcely seeming to be alive; but after sundown, when I would suddenly switch on the light, I surprised it in the act of swimming or generally roaming around the tank. Later familiarity with kindred and other members of its class revealed that the group as a whole is probably altogether nocturnal in habits; or, which amounts to the same thing, in all their adult activities such as searching for a meal or a mate, they seem to carry on, so to say, under the cover of darkness, always shunning the light of the sun. It may also be pointed out here, in passing, that these animals are normally the inhabitants of the deeper water, their chance presence in the shallows near the shore being largely the result of storms or of strong wind-driven tides; consequently, living, and having lived for ages, as they do, in a habitat naturally dark or gloomy, they have inherited strong instincts, thus reacting negatively to light, knowing that when in the presence of bright day they are far from the protective obscurity which is theirs in the nether-grayness of their native depths.

Having now the dead serpent-star on my hands, I proceeded at once to pickle it in preparation for a minute and careful examination; and nightly thereafter, for the space of several weeks (for my daylight hours were then devoted to other and more urgent duties), the room reeked with fumes of preserving fluid. And it was then that I learned something of Ophiuroidean anatomy in general, and considerable of the frame and the physiology of *A. squamata* in particular. I learned in the first place, with the aid of books, the technical names of the various organs and parts of my serpent-star, and all else regarding their functions that is to be obtained from reading. In this manner I came to know that these creatures are somewhat like their far-removed but more familiar relatives, the common starfishes of the shore, in that their bodies are composed of a central disk with five rays, or arms; but, also, they are unlike them in having the arms distinct from the body, that is to say, the arms are not merely prolongations or extensions of the disk. They differ, too, in their method of locomotion. The serpent-star swims or moves by actively wriggling its arms; the common starfish progresses at a slow crawl by the alternate movement of hundreds of sucker-feet aligned along its under surface. No such sucker-feet existed on my animal; the arms were simply lined at the sides with rows of spines which projected from each of the many joints comprising those members. Nor did it have a vent. The digested food was excreted through the mouth. And it was in this region, I was informed, that the madreporic plate, or sieve, was to be found. What purpose this served, since the serpent-star was devoid of sucker-feet, was not made clear. In the common starfishes, the madreporite is on the animal's back; it acts as a strainer of the water wherewith their multitudinous feet are distended and contracted. But I shall have more to say about this, later. Other details I learned besides—too technical or uninteresting for repetition here—and I then essayed to discover what I could on my own account.

Thus the first thing that struck me was that this animal lives entirely within its own skeleton. No integument or skin of any sort invests its gray calcareous frame. However, there emanated from each side of the arms, just below the spines, a row of tiny tentacles, or so-called tube-feet—so-called by the books, but their function is not that of walking. The next striking oddity was the utter absence of eyes; nor were there to be found any pigment spots which, as is often the case in lowly organized animals, could by any suspicion subserve the purpose of an organ sensitive to light.

Then began the delicate task of taking the creature apart—a task wherein my new microscope now stood in good stead; it was, in fact, entirely with the aid of that instrument that the operation was performed. The results of this latter bit of research were far more noteworthy; and they were three: the discovery of the first clue to its food habits; the learning of its probable method of breathing; the finding of the equally probable cause of its premature death . . . All of which, however, must await the future study of living subjects for corroboration.

As I have said, two years elapsed before that opportunity came. In vain did I search every likely spot along the shore. Once, indeed, I did come upon a mutilated specimen thrown upon the beach by a recent storm. Its like I had never seen described; it was undoubtedly a new species; so I gave it my name—on which score I expect to become famous. As it offered nothing beyond what I had already learned from my previous example, I continued to be still far from my goal. But it was really through this creature that I was led into the light. Taking it down from the shelf where it reposed in a vial of spirit, I was examining it for the hundredth time on a morning of the forementioned June when the light whereof I speak broke in upon me. In an overwhelming flash it occurred to me—what has undoubtedly occurred to the experienced reader before this—that since I was wasting my time along the shore, it might be well to try the deeper waters of the Sound.

With what success these newly-inspired efforts were attended, we have already seen from my tanks. Daily and careful dredging had accomplished more in a single week than had been achieved in all the previous months of laborious search. So I now prepared to pursue my studies with a vengeance. I would retrieve by constant industry and intensive application the time that had been lost by my near-sighted negligence. But how should I begin? As the situation stood, I was confronted with the question of making continual observations of the animal and noting the results as they might occur in their natural course or sequence; or I could proceed on the information already gained, and work along such lines as to establish the soundness of the conclusions I had drawn therefrom. That is to say, either the inductive or the deductive method could be employed. I decided on the deductive.

Thus far, of course, my known facts were meager and were based entirely on the examination of a dead animal, but their elaboration entailed practically the complete knowledge of the creature's life and habits. It may be well, therefore, briefly to review in numerical order some of those facts and the deductions I made in each instance before taking up the evidence of the tanks themselves. But lest it here appear that this is written with an air of what-a-smart-fellow-I-am, I wish to anticipate the reader and ask that he form no opinion until the agreement of my deductions with later findings is revealed.

Fact Number One concerns its skeleton. Here I must recall that the disk of the serpent-star is composed of a number of fused plates, the whole, with the exception of the five triangular processes forming the jaws, being a rigid naked framework; while the arms consist of numerous ball and socket joints, like the backbone of a vertebrate, and are, aside from two minute passages running throughout their length, and the cavities containing the muscular attachments, almost entirely solid in structure.

Therefore, I reasoned, from an evolutionary standpoint this solid structure was predisposed by a long continued mode of life under great pressures. Great pressures indicate depths at which plants do not grow. Consequently it must be carnivorous. Also, being an active creature, it undoubtedly subsists largely, if not wholly, on living prey. And this prey it captures by scent and contact as it roams around over the unlighted floor.

Fact Number Two had to do with its lack of vision. This absence of eyes supports the theory in Fact Number One, wherein it supposes that the roving animal smells and feels for its food.

Fact Number Three regards what was actually found in the dead serpent-star's stomach. Like Fact Number Two, this supports part of the conclusion in Fact Number One. Although in this instance digestion was so complete as to make the nature of the stomach contents generally unrecognizable, the microscope revealed a fragment of a tiny leg of what was an undoubted crustacean—probably an isopod.

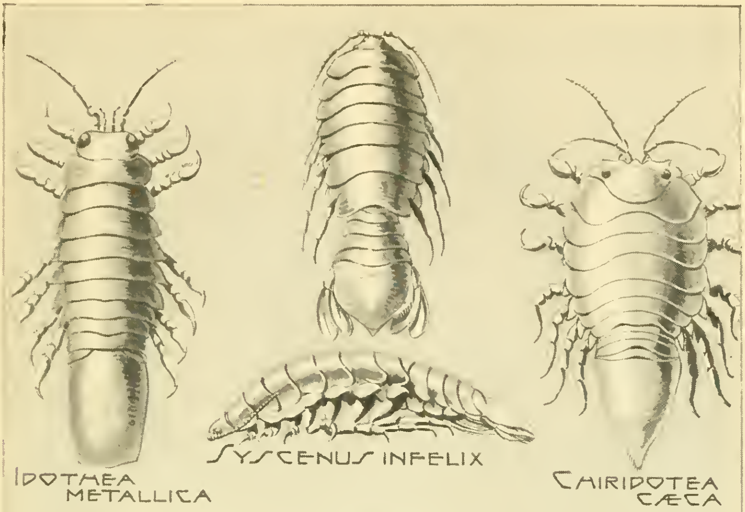
Fact Number Four relates to its breathing. In my serpent-star I traced what is known as "the water-vascular system." This, in the common starfish, is nothing more than a hydraulic bellows arrangement whereby each one of its tube-feet is made to distend or to contract in the act of walking; it probably has no part in that animal's respiration, this function being assumed by the multitudinous dermal branchiæ, or breathing-organs on its back. This system is blind at the terminals, which is to say, the tube-feet, but it opens at a point on the upper side of the disk, where it is protected from the invasion of silt and similar foreign matter, by the sieve-like madreporic plate. Now, as my serpent-star was destitute of dermal branchiæ, and as it was further devoid of gill-like organs, both externally and internally, it obviously was only through the otherwise useless tube-feet that respiration could be effected. More; I argued that the entire water-vascular system was in addition a sensory apparatus: the madreporite at one end being the olfactory center, while the tube-feet at the other were the tactile organs.

Fact Number Five. This fact, the most indisputable of all, was that my animal was dead. But from what cause? Naturally the only answer to this was that death resulted from its abnormal environment. Its injury may have been a contributing factor (although this was extremely improbable) but it was not the chief cause, as no vital organ was affected. Therefore, wherein was my tank lacking that it led to the creature's killing? I suspected at first that pressure—or rather lack of it—might have had something to do with it; but when I recalled that these animals are often found in a healthy condition close to shore, this theory lost its attraction . . . No. Deductions could not be drawn here . . . Yet somehow I felt that if I could solve this problem, the solution to the entire business would be reached with comparative ease. Nevertheless, in the remote recesses of my mind, there persisted in lurking a vague haunting suspicion. And a suspicion only, it remained; until an event occurred that resolved it into something considerably more than a mere suspicion.

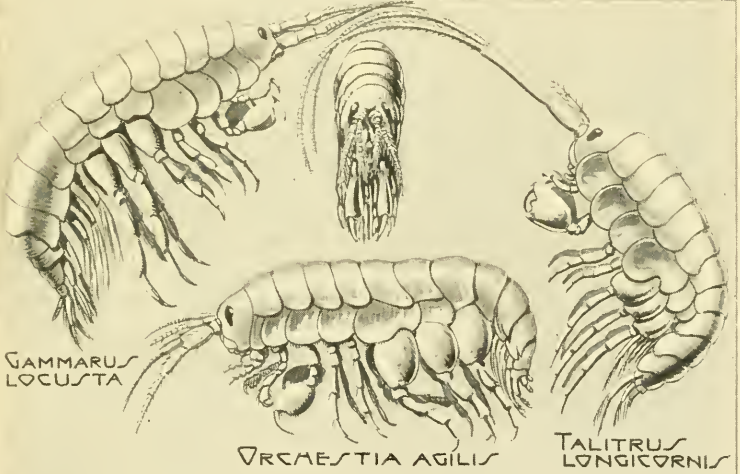
This event was the further fact that on the morning after that bright June day which passed with so much promise, I found that every serpent-star in my tanks was either stark dead or rapidly dying! . . .

IV

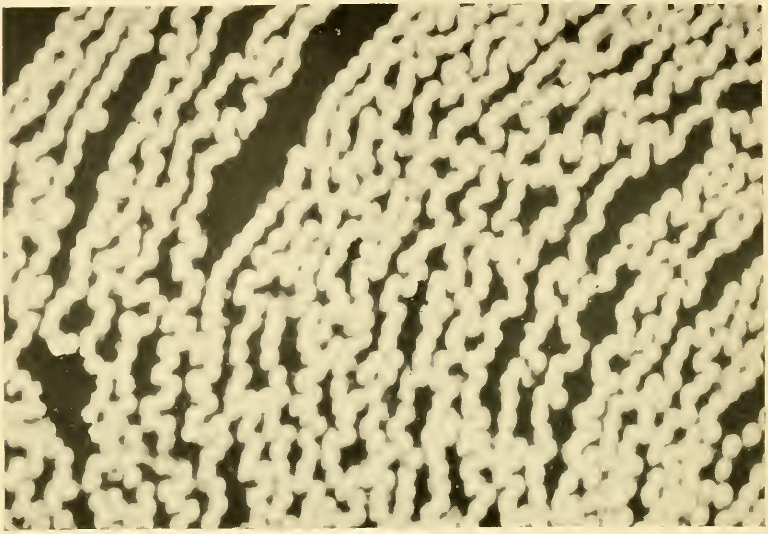
Perhaps it will be well here to anticipate my conclusion somewhat, by saying at once that as it later turned out, I was considerably wide of the mark, yet, in a way of speaking, I was not unreasonably wrong in forming the foregoing deductions. Now, nine times out of ten, deductions such as these, in the case of most observers and with similar data, would be not only inevitable, but also safe. Well, in regard to the inferences eventually drawn —from the death both of my former individual and the ones just mentioned—it seems that I was right as well as safe. Without further preamble let me say that I had fixed on low salinity as being the inherent cause of those disastrous occurrences. The containers in which I had kept these creatures were filled with sea-water taken near the shore; and this water, while not brackish enough to affect other types of animals which I had been wont to keep, was, I suspected, in salt and other chemical constituents, insufficiently concentrated for so obviously delicate an organism successfully to adjust itself. That healthy serpent-stars occasionally are found near the shore—such as was my single spec-


IDOTHEA METALLICA
SYSCENUS INFELIX
CHIRIDOTEA CÆCA

ISOPODS

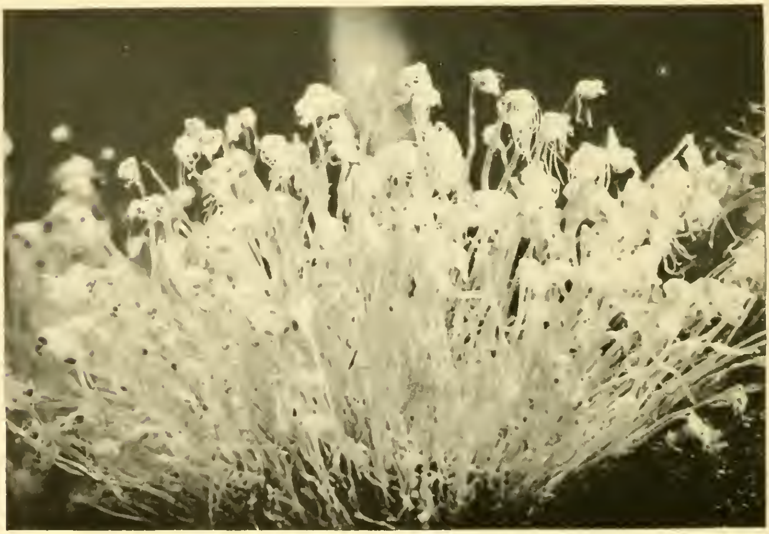

GAMMARUS LOCUSTA
ORCHESTIA AGILIS
TALITRUS LONGICORNIS

AMPHIPODS



EGGS OF A PLANARIAN FLATWORM

Enlarged twenty-seven times



THE PASSION-FLOWER HYDROID

Natural size

imen—is a brilliant example of wherein the exception proves the rule. For their active presence in the shallow shore-water is almost invariably coincident with a season of terrestrial drought: when the sea is little diluted by the added rainfall washing from the land.

As to the soundness of the interpretations of my other facts, let us pass over the space of a month, let us turn to the tanks to see what testimony is therein vouchsafed.

Thus we find ourselves as before, except in relation to time. It is now just past three o'clock in the morning. The darting beam of my electric torch picks out various objects as I pass along the familiar bench, revealing that certain changes have been made in the arrangement of a month ago. The same tanks are here, the same seaweeds thrive in them; but for the most part they are occupied by different creatures. Not a serpent-star is in evidence. Here is one with a holothurian, its purple tentacles weaving about over the spot where it has sunk its body into the sand, and as my light plays on it for a moment, the sensitive feelers suddenly retract, then slowly expand to resume their weaving. Close at hand is another large glass affair holding its near relations, the sea-urchin and several sand-dollars. Lights and sounds are emitted at intervals from occasional tanks near-by; such as the phosphorescent flashes of comb-jellies and the clicking shells of brawling hermit-crabs. But all this can receive little more than a perfunctory notice from me now; I move away, not without some feeling of reluctance, however, and continue toward a door at the end of the laboratory which opens into a photographic dark-room.

Switching off the lamp, as I turn the knob and close the door behind me, I find myself in absolute darkness. Then groping my way to a table at the side, I feel over its top until my hand comes into contact with a cold hard surface which I know to be an aquarium containing the purest Sound water and an even dozen serpent-stars—all that I possessed, but all thriving as well as on the date of their acquisition a fortnight since. The hum of a small motor can be heard, as it works the pump supplying a stream of bubbles to this miniature replica of the sea floor. For the tank has no seaweeds to aërate it—the presence of plants being worthless in the dark—nor does it hold besides the serpent-stars anything else but the aforementioned water, at the bottom of which is a thin layer of grayish mud.

This nocturnal visit is but another of many periodic observations made every two hours for these several days and nights past. That, during the daytime, I should keep careful check on the activities of the serpent-stars, might be accepted as a matter of course, as being part of the naturalist's routine; but that I should throughout the hours of darkness interrupt a dreamless slumber at regular intervals, to steal, flashlight in hand, into this room like a thief in the night, would indicate a purpose to purloin secrets more precious to me than gold. This, in truth, is well within the fact. My absorption in the serpent-star is now such that nothing else matters. And why should this be surprising? Have I not constituted myself a spokesman of all these lowly dwellers of the sea? Surely I should not be worthy of the office were I unwilling to sacrifice somewhat of sleep. Besides, many are the moments of unalloyed joy which their confidences confer; but aside from this there is an interest, a fascination to workings of their mysterious ways that is fraught with a thrill, a pleasure apart—but why set it down, these are esotericisms that, no matter how painstakingly arranged, no words in our language can quite make clear. Briefly, fortune at last was on my side—or was it by perseverance I had won? . . . Within the two preceding weeks I had cleared up the five major points concerning the unanswered questions of the past two years. In addition I had come upon another matter of equal import; and it is this which occasions my periodic pilgrimages to the darkroom.

By keeping these animals in darkness, I tried to simulate as nearly as possible the conditions which prevailed in their natural habitat. A further reason for this seclusion was that it enabled observations to be made at any time, even during the hours of daylight. I had found, too, that though they remained inactive when continuously exposed to the glare of day, they seemed not seriously to mind the shorter exposures to my artificial light. I say "seriously" in the sense that they did not alter markedly in their behavior: always there was a definite reaction to sudden illumination, which was soon followed by their resuming their interrupted activities. Witness now what happens as I flash the lamp on this early-hour visit.

The sudden stream of light catches our creatures unawares. But what is this? . . . Not tiny *A. squamata* of my early experience: it is the species *Ophiopholis aculeata*, the most beautiful and most conspicuous and perhaps the largest species of all ophiurans. The individual members are full-grown, each arm measuring three inches in length while the disk is three fourths of an inch in diameter. In color they are spotted with large patches of purple on a background of golden yellow. No longer can I refer to one of the animals as "it"; unlike little *A. squamata*, which is a hermaphrodite, the sexes in this newer species are separate. *A. squamata* differs also from these in that it does not strew its eggs into the water to be fertilized and hatched, but carries them in its disk until an adult-like form is developed.

Here I must inform the reader that in accordance with the common hazards of dredging, I never again came across another *A. squamata* in my locality; nor had I found other kinds in sufficient quantity or sufficiently vigorous to use for observation. So I did the next best thing. I did what every student does when he is pressed to obtain rare material; although I do not recall having seen this admission before in print. I collected by proxy. To a fisherman plying his trade at the eastern end of the Sound I confided my desperation, with the result that I was soon supplied with the species mentioned but commonly known as "Daisy Brittle Stars," and probably the only serpent-star bearing a popular name. Well, no matter—the questions we are about to apply to *O. aculeata* will receive the same answers when put to any other member of the group.

Of the dozen inmates, but five are visible; and these can be seen variously distributed over the muddy floor of the aquarium for the most part motionless except for their arms which keep sweeping in a sinuous fashion the area within their reach. They are feeding. On the silty bottom, barely visible by reason of its dark color and fineness, is a generous sprinkling of algal material largely composed of diatoms, supplied but a few hours before. Here a sharp eye is necessary if one would see the method. The rows of tube-feet extending along the under side of each arm exhibit a rhythmic wave-like movement much as would the teeth of a comb when the finger is slowly passed over the points. This movement is toward the central mouth and it carries along particles of the edible material. Yet, so sensitive and selective is the touch of these tentacular fingers that little if any of the surrounding sand grains find their way to mouth. That their function is olfactory rather than tactile in determining the proper substances is proved by an experiment I am now about to make for perhaps the hundredth time. From a dish of relatively fresh clam broth close at hand, I select a tiny fragment of filter-paper thoroughly impregnated with the liquid. A similar piece of paper, but without previous soaking, is also made ready. Then with a long forceps I lower the clam-steeped fragment to a point over one of the serpent-stars and let it settle down within the radius of its rays. Immediately this is followed by the unprepared paper. No sooner does the arm come into contact with the first piece than it starts to maneuver it toward the mouth;—indeed, the creature becomes eager; it does not await the completion of this slow procedure, it moves bodily over the fragment and ingests it. Not so, however, with the other bit of paper. One or another of its arms repeatedly touches it; but always with total indifference.

This experiment, obviously, proves another thing: the ophiuran is fond of flesh. But not as I had deducted from Fact Number One in this chapter, does it subsist on living meat. Let it now be known: our pretty serpent-star is a scavenger. The game it bags must already be dead; and it seems to like it better when it is rather "high." It is doubtful if it could capture anything that moves, if it would. Its fragile frame is not adapted to the pursuit of prey. In the battle to maintain its place in a region of darkness and pressure, it was deprived of the weapons that prevail with those of its kindred who dwell in the light.

Thus it will be observed that the hypotheses I built on Fact Number Two and Fact Number Three have also partly fallen flat. And now we come upon something concerning Fact Number Four and Fact Number Five and the accuracy of the remaining deductions.

As I have pointed out, but five serpent-stars are visible. It would not, however, be hard to guess how and where the others are employed. A movement in the mud at several places on the bottom indicates the presence of one or more individuals. They make their way here and there under cover with the same object in view as their brethren above; namely, for food. But in this instance their selective mechanism seems not to function so well; for in dissecting one of these burrowers, we will find in its stomach numerous sand-grains along with the diatoms and other one-celled plants it has swallowed. Whether the habit of burrowing has modified their structure, or whether their structure inclines them to bury themselves, is a matter I will leave to the evolutionist; at any rate they admirably overcome the handicap of an awkward form in boring for their food. A worm, a notoriously soft-bodied creature, manages this thing because of its linear shape; the serpent-star with its radial arms accomplishes the same end by its armor and its greater strength.

Presently an arm is pushed out of the oozy silt, just beyond the circle of my light. I catch its gaudy pattern, nevertheless, and watch it for a moment as its writhing form explores the adjacent region. Then with a sudden movement I flash the full intensity of the focused beam directly upon it. There is a pause in its groping; then slowly it retracts and disappears. This hide-and-seek game we play for a while when I decide to repeat another experiment.

Removing my light far enough to avoid further interference with the actions of the buried animal, I select a long glass pipette with a rubber bulb at one end, and fill it with fresh water from the tap. Holding the filled tube in the tank until its temperature is equalized, I bring the tip close to the protruding arm, and give a slight squeeze to the bulb. The reaction is instantaneous. Without further preliminary the arm is whipped out of sight and the excited movements of the serpent-star can be traced in the agitated silt as it wriggles away from the spot. The same procedure takes place with the others that I attempt to test. Always there is the same response, the same sudden and powerful recoil. In effect, the fresh-water seems like a violent poison.

From the foregoing at least some of the mystery of the serpent-star begins to clear. Although this creature has no eyes, it is sensitive to light; therefore, after a fashion it can see. And as the tube-feet are the only external tissues supplied with nerves, it is not improbable that it is these that detect the light. We have just reviewed evidence that the function of the water-vascular system involves breathing, feeling, and smelling. But it has another capacity also, and one which is of enormous protective value to the animal: it enables it to sense the deleterious presence of fresh- or brackish-water. In short, this system is hydrostatic as well as hydraulic. In passing, let me say that if further proof were necessary that brackish-water is harmful to the ophiuran, I need refer only to the fact that within the preceding week four serpent-stars were placed in my ordinary tanks with the result that three died before two days had passed. The remaining one was recovered before life became extinct, by transferring it to its proper medium here in the dark-room.

Now it is that I notice a hazy cast seeming to concentrate in the region of my lamp which has remained stationary while I occupied myself with the various reactions of the inmates. This haze is of the most tenuous tint of blue, barely perceptible, and at the moment would probably not attract my attention were I not anticipating something of the sort. It was in expectation of this that my nocturnal visits were chiefly inspired.

My statement that there were twelve serpent-stars in the aquarium now needs modification. The literal truth is that there were not fewer than a million. Not many hours before, I discovered that my animals had been spawning. The eggs had now just hatched, and the faint cloudiness is the swarming mass of microscopic larvæ drawn, by what force I know not, toward the brilliant beam of my electric light.

No microscope is necessary, however, to tell me what the individual units look like. The pluteus larva of the serpent-star is long familiar to me as a strange figure in reference books, delineated in pictures as a transparent pyramidal mote entirely unlike its parents, and in the text as a swimmer at the surface of the sea with the aid of innumerable vibrating hair-like processes which cover its exterior.

Nevertheless, I know that many hours at the microscope are now ahead of me. I know that I shall pore over it with the wonder of one who has never seen its likeness actually or in print; I know that I shall not remain content until it has told me its own story of changing shape and development preceding the attainment of its adult form . . . And I know, too, that after all this has been done, I shall only have repeated the experience just ended with its parents—which is to say, of the real serpent-star I shall have known little more than nothing.

CHAPTER THREE

More Problems

I

ANY one looking for proofs to substantiate his theory seldom has trouble in finding them. Still, I think that it will require no straining of the imagination or convenient warping of facts to arrive at least somewhere in the neighborhood of the truth regarding the why and the wherefore of the ophiuran. If the reader has followed me in the preceding chapter with any interest at all, he cannot have failed to perceive that it is in a sense incomplete. But the history of the mere further physical development of the serpent-star can be told in very few words, and at best it probably would be attractive to only a few others beside the technical person.

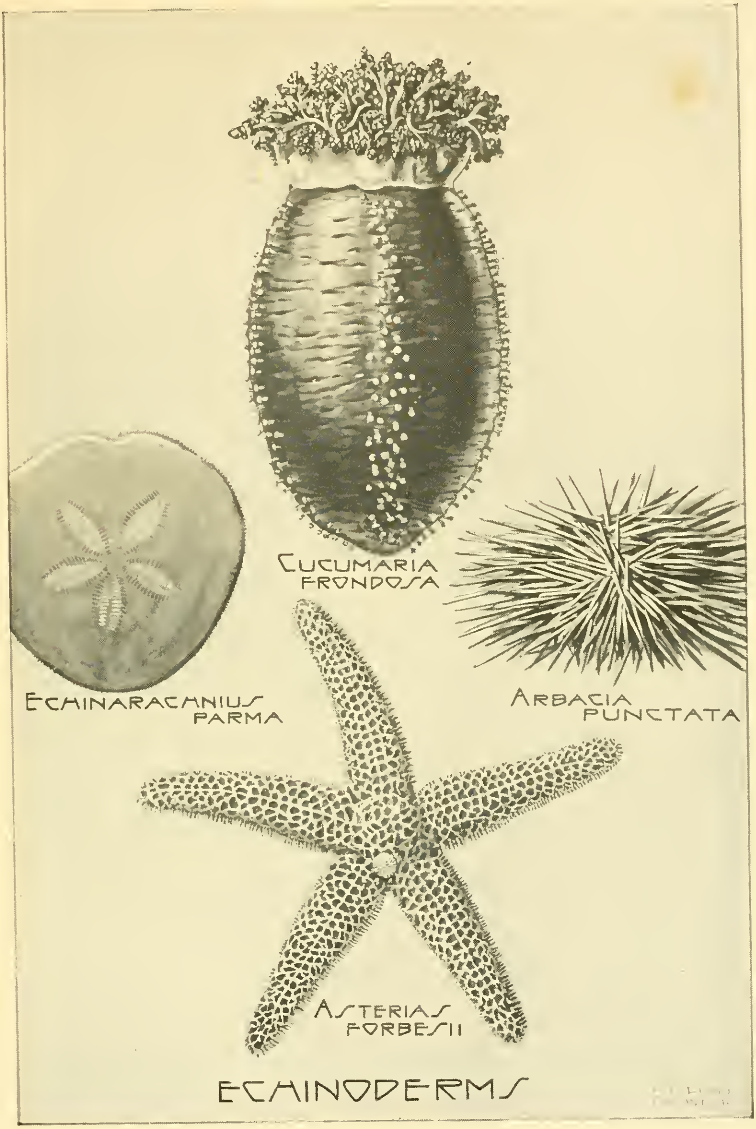
The background of that history, however, is quite another matter. It is absorbing alike to all; it reads like a romance. It is in reality a romance of the ages; and it is recorded in the most enduring of all books, for they are the solid stone of our earth. So from an altered point of view I shall attempt to bring into relief some features of that background, without which the natural history of the serpent-star cannot readily be appreciated or understood.

To begin with we will go back several million years or so to that day when the first known forms related to the present living ophiurans were supposed to have thrived; but while stepping backward, so to speak, let us linger for a moment on the way in order to gather some material for a better rendering of the picture.

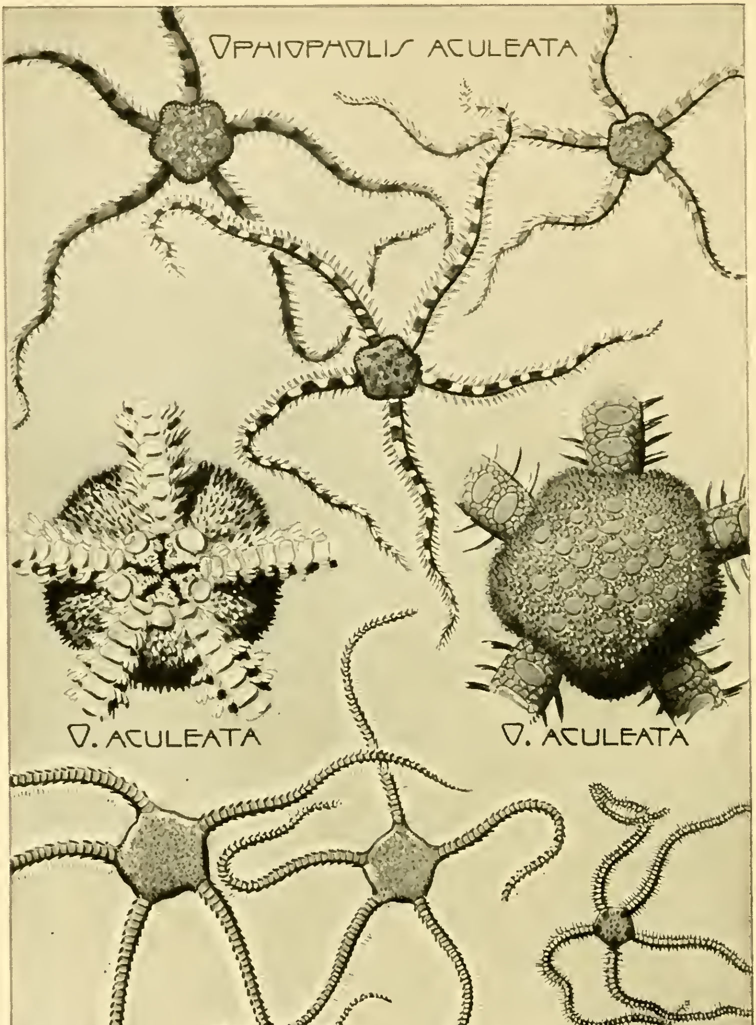
This finds us then some time in the year 1893; thirty-five years from the time of this writing—which is to say when I was eleven years old. In that year a biological event occurred which, while not rocking the rest of the scientific world with its importance, was to one scientist, at least, a phenomenon of the very first order; for during a certain night of that halcyon year—that immortal year, which long later was to prove so profound in its potentialities—a brood of sow-bugs was born . . .

To my young and (until that period) rudely tutored mind, this marvel awakened me to new vistas; I perceived for the first time the possibilities for the marvelous that lay in the study of natural science—although the phraseology and the terms of this sentence were then unknown to me. I had known, of course, that the cat bore kittens and that a cow had a calf, and even that a wolf had pups; or so I had heard my father say, as he often ventured his opinion, that this symbol of poverty was not merely at our door but also well within certainty of having its litter right under his bed. Otherwise, I had thought—if indeed I then gave such matters any thought—or had taken it for granted that such creatures simply happened.

My premier observations of the lowly had been inspired by an Illinois village school-teacher; a woman, the like of whose understanding of her pupils (this pupil in particular) I have never known again. Before I had come under her benign yet firmly given instruction, my quarrel with letters, and learning generally, had been standing ever since I first went to school. And I may as well add that that quarrel was renewed as soon as I left her at the end of the term; for four years more in


CUCUMARIA FRONDOSA
ECHINARACHNIUS PARMA
ARBACIA PUNCTATA
ASTERIAS FORBESII

ECHINODERMS


OPHIOPHOLIS ACULEATA
O. ACULEATA
O. ACULEATA
OPHIURA BREVISPINA
AMPHIPHOLIS SQUAMATA
WILLIAM CROWDER

SERPENT-STARS

the State of Iowa, to where my family had moved, I labored along, the most indifferent of scholars, finally leaving school, in the seventh grade, at the age of fifteen. Certainly in my own instance the child was not father to the man. The future naturalist-artist-writer was not then adumbrated in such commonly-assumed juvenile attributes as studious habits and a preoccupation with beauty or books. Such pursuits did not become the serious business of my life until I was well past my majority; in my boyhood I seldom gave them a thought. My ambition then lay in a far different direction—Reader, do not gasp, I wanted to become a prize-fighter. My models, therefore, were not Agassiz, Wuerpel, Macauley, *et al.*, but John L. Sullivan and James J. Corbett . . .

Well, I did become a prize-fighter. And now I must expose something which I have concealed in the opening chapter. It was from the proceeds of one of my pugilistic affairs that I was enabled finally to buy my first microscope.

But if the adage just paraphrased in a preceding sentence does not hold good, another as homely, though trite, surely will: As the twig is bent, so the tree is inclined. For it is unquestionably due to this teacher's inculcation of her own love of nature and art and literature that I have shaped my own career. The seeds she planted, admittedly, were long in germinating, but, at any rate, they never died. She did the best she could with the soil at hand. So if the fruit of my experience bears no further promise than this, that it inspires courage in some chance reader who has perhaps lost faith in the future because of a seemingly misdirected past, her husbandry will have been well worth the labor.

O Paragon of Pedagogues! How can I repay my debt to you! How well I remember that patience and forbearance which was yours, when cloyed with the day's monotonous round you sought in after-hours to instil in this benighted urchin's breast a fondness for the finer things of life. Nor have I forgotten your private treasures edifyingly displayed for my wondering eyes alone—your sea-shells, beautiful beyond utterance; but your descriptions of their identities, luminous, revealing; your minerals, rare in kind, radiant in color, all arranged in becoming order in their pretty boxes of delicate robin's-egg blue; your stuffed pelican, standing stark, immobile on its ebony base, yet alive and alluring in those tremendous moments that you transport me to its semi-tropic home by the magic of your words . . . Nor that little notebook which you gave to me—so sharply does its image stand after these many years! On its crimson cover was a pictured globe beneath which was born the enticing title "The World for One Cent"; across the top you had inscribed my name and words "Rock Falls Public School, Room 5, E. Grace Mann, Teacher." In its precious pages you taught me to keep my first accounts of the trees, the ways of the flowers and the insects, and the birds and other creatures which I began then for the first time really to observe . . . Nor the poet Whittier's picture, framed by the contributions of the class, unveiled in solemn ceremony whereat you predicted the return on some far distant day of one of the assembled students who would seek that room again to reveal once more the signatures of his fellows affixed on the back of the portrait. Your prediction came true. I recently revisited the old school-room. The picture was still there . . . but you, and nearly all my former school-mates, had left those sacred precincts long, long ago, had disappeared utterly, leaving behind naught of yourselves but a recollection . . . Dear Teacher, I wonder where you now are. I wonder if you in turn ever recall the little freckle-faced barefoot boy who amazed you by memorizing "The Chambered Nautilus," the printed verses which you so graciously presented on his birthday. The years disperse as inexorably as they efface; but wherever you are, whether it may be yet among the living or whether with the dead, no tribute of mine can begin to compensate for the inspiration I have derived from your tender, your sweet and noble memory . . .

II

Thus, it will be observed, came about my first real revelation of one of the manifold secrets of Nature. It will be further observed, if you please, that the subject of my inquiry was a crustacean; for the sow-bug notwithstanding its strictly terrestrial habits is a member of the group comprising also the lobster, the shrimp, and the crab. These land isopods, as they are technically known, are found everywhere, far from their ancient home in the sea, frequenting damp situations and dark nooks such as are offered by the under sides of stones and decaying logs. So, in a sense, it quite properly may be said that my subsequent concern with seafolk was determined by this early contact with one of their related kind.

It is supposed that all organic life now inhabiting the land and its streams and ponds, came from ancestral forms originating in the sea. Of the forms living on dry land, few have remained so little modified in general appearance from that of their forebears as the familiar sow-bug. It is an air-breather and will no longer survive submersion in either fresh- or salt-water. In fact, beyond certain subtle differences in its abdominal respiratory appendages, it so closely resembles some nearly related marine isopods, that by the inexpert it might easily be mistaken for them. It is doubtless the most ancient of all creatures, with the possible exception of the worms, living to-day strictly on the dry land. By some authorities it was only recently held to be a direct descendant of the trilobite; one of the few of the very oldest creatures that left their fossil remains in the rocks. But it seems that still other authorities hold quite different views; these deny that the trilobite is even a crustacean, they aver that it is an arachnid; which is to say, it belongs with the spiders, its present-day descendant being *Limulus*, the horseshoe-crab. The horseshoe-crab, it should be pointed out, has a peculiar embryology and development, very unlike that of a true crustacean; and for that reason its relationship with any living group is a problematical one at best. Its ancestors, too, were among the earliest inhabitants of this earth to bequeath to posterity the first fossiliferous evidence of undoubted animal types.

There is one group, or phylum, of marine animals, however, of which since the time of its most ancient day no record has been traced. It was ancestral to no land form, living or extinct. The echinoderms, to which our serpent-star belongs, have not now, and never have had, any relatives near or remote living away from the sea. In this isolation they are unique. Nature seems somehow long ago to have abandoned all effort to lift them to a higher plane; the modern representatives appear not to be greatly altered in form during these millions of years since their ancestors turned to stone.

That they have changed since those days, is inevitable; but they have nowhere given rise to higher and more specialized forms, such as are to be found among the other groups. Their evolutionary progression has been slow; and if we cite the sea-cucumber as an example, which is worm-like in even more ways than its appearance would imply, this is one instance in which it seems there has taken place actual regression.

If abundance of fossils may be taken as a criterion, the dominant echinoderm of ancient times was the crinoid, or sea-lily. Reduced to the simplest of terms, a description of the crinoid would identify it as a starfish attached by its back to a long, jointed calcareous stalk, and oftentimes bearing slender many-branched arms. As the crinoid is firmly fixed to the spot where it grows, and as it has no weapons of offense or defense, it relies only on its armor for protection; its cup-like body is composed of rigid plates, while the stalk and the arms surmounting the cup are hard nearly throughout. It acquires its nourishment by the wave-like action of minute hair-like processes, or cilia, arranged along a groove on the inner side of each arm, these cilia sweeping the fine drifting particles of suspended food material toward the central mouth at the base of the arms. Its habits of to-day, as well as its appearance, are not essentially different from those prevailing in the past; this is probably due to its unchanged environment. For the cataclysms, the great climatic changes and other natural convulsions which apparently have been potent factors in the evolution of land life, seem never to have exerted any effect on conditions in the deep sea; here, from the most remote period of which there is even plausible proof of life, just as now, it has continued cold, dark, immutable. And so the crinoid, rooted in the oozy bottom, its ghostly flower-like form swaying invisible in the icy unlighted depths, remains the only living relic of that former age, least affected by the passage of time. But to-day it is only a remnant of a once numerous clan. No longer do its beds cover great tracts of the ocean floor; of the two hundred odd genera that formerly thrived, it is doubtful whether more than a dozen now exist.

But the starfish, serpent-star, and sea-urchin were also on the scene in that early Silurian time, though evidently their numbers, comparatively speaking, were few. It is not unlikely that the sea-cucumber, too, was somewhere around, but no fossils betraying its presence previous to the forming of the coal beds have been known to occur. Like their stalked cousin, the crinoid, these free forms appear to have been furnished with cilia for the wafting of food to their mouths.

From this latter fact alone, the inference is inevitable that all echinoderm forms prior to their appearance as indicated by their fossils, were fixed; that is to say, they were stationary animals having no locomotor appendages whatever. However, it is from another kind of evidence that I shall attempt presently to prove, as fully as such a thing can be proved, that this was actually the case.

In speculating further on their early history, the question next arises as to what was the primitive form, what was the appearance of the first echinoderm, what were the salient features of that most ancestral creature whose descendants diverged to form the five classes into which the group is now divided.

As idle as this speculation may appear, it is, nevertheless, possible to find a few helpful fragments of information among those foundation stones of natural science known as embryology and morphology; and with these pieces, a passable primitive ancestor can be reconstructed. But as it is not my intention to burden the reader with technicalities, I will pass over the method of procedure and come at once to a brief recapitulation of the results. Later, in my laboratory, we will give closer attention to certain of those steps that lead to these results.

It is reasonable to suppose that the primitive echinoderm sprang from some ancestor proportionately longer than it was broad and which was symmetrically alike on both sides; features such as distinguish the worm. Now, as the reader has doubtless suspected, and certainly as he will fully discover before proceeding much further, I am convinced of evolution. Still when I assert that it is "reasonable to suppose" a worm-like creature as the prehistoric parent of the present serpent-star, I do so not merely because of a blind faith in words, in the dicta of the learned doctors, armchair theorists whose knowledge of Nature is largely gained from long and arduous rumination in front of a museum cabinet-shelf; it is rather in spite of them, it is because I have tried to sift at first hand, for my own satisfaction, the evidence that tends toward this view. I am a naturalist; and

I come by my convictions inevitably and by reasons peculiarly persuasive to one of my calling. These convictions, of course, I stand ready with either my mildewed gloves or my typewriter to uphold. But to enter upon a discussion here of the causes underlying their attainment is aside from my purpose; to do so would far overshadow the main subject. Yet as deeply as these convictions prevail, I remain always in equal readiness to renounce them should other and cogent reasons fully as persuasive arise. Therefore, I can only request the reader, regardless of his belief in evolution or his opinion of these matters generally, to bear with me the while I attempt to outline the main features of the ancient echinoderm. Whether or not the image will be ideal cannot, obviously, be affirmed positively; nor is this so important right now. It will at least be interesting, however, in the light of what is later revealed by the larvæ in the laboratory. And I merely present it for what it is worth, letting the reader form his own conclusions. I assure him I have no lurking desire to be the Bryan of Biology or the Straton of Science-at-large.

Giving our consideration then to that form which, it is supposed, presaged the echinoderms, we infer that it was somewhat as follows: It was a soft hyaline creature, totally without external spines, plates or other hard parts, but possibly contained a spicular skeleton. At the extreme forward end was a sensory organ indicated by a cluster of long cilia, perhaps the only seat of sensibility through which it was enabled to apprehend the outside world. Beside the probable paired water-pores on its back, two other orifices were present: the mouth, located underneath near the front; and the vent, situated somewhere close to the rearward end. It was devoid of external appendages except for locomotor cilia which covered the entire body. These cilia were shorter than the sensory processes, and it was by the aid of their vibratory movements that the animal swam. Indeed, it was an unceasing swimmer, seldom, if ever, pausing to rest; and it swam at, or very near, the surface of the sea. But the arriving echinoderm is not yet; in none of these structural features is represented the peculiarities of the modern adult.

Nevertheless, this anomalous creature was plastic, so to speak; it was awaiting only some great and influential factor to arise, causing an alteration in its destiny and consequently a change in its habits and in its very form. That factor arose: it was the finding of the floor of the sea.

This was a momentous event in the history of the echinoderms as well as in the life of *Dipleurula;* for such is the name that science has given to our more than hypothetical creature. Now ensued those changes in the structure of the latter which inaugurated the former as a phylum. As the sea-bottom could be apprehended only by the sensory end, the foremost, it was by that end that *Dipleurula* affixed itself, eventually becoming permanently attached; not at the tip, however, precisely where the sensory organ was, as that would interfere with its functioning; but slightly to one side. Thus, with *Dipleurula* literally standing on its head, begins the first echinoderm.

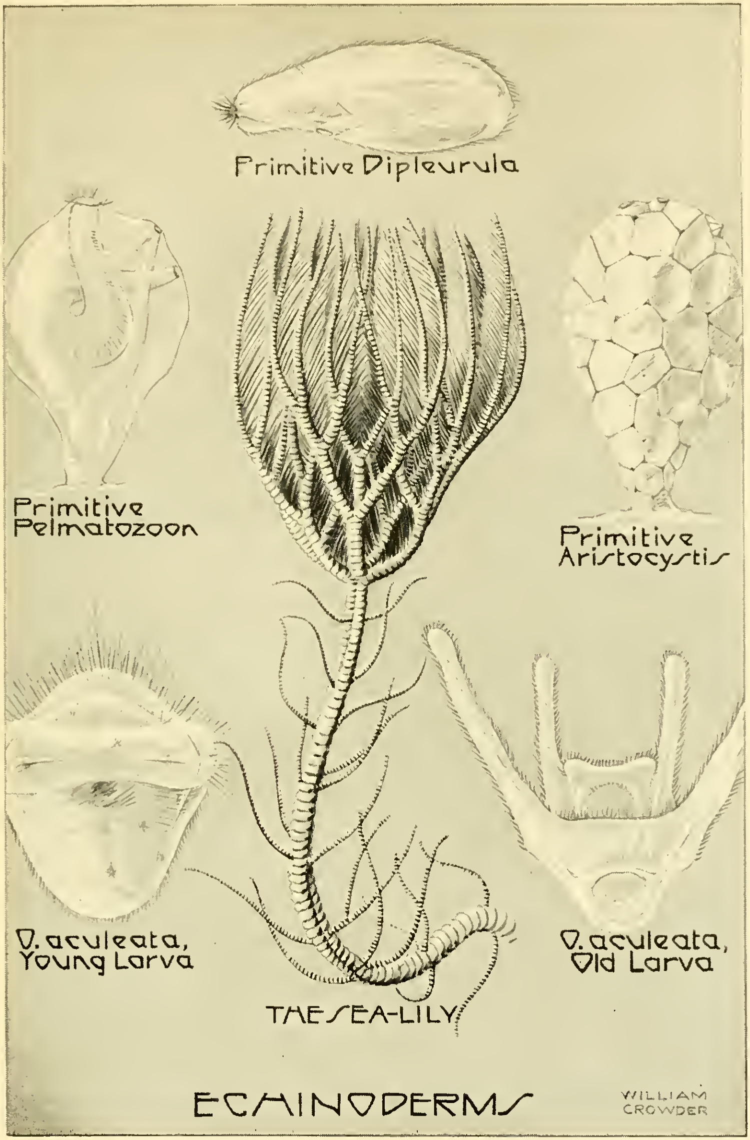
But see what now happens. The mouth travels upward—the inevitable result always to be observed in such instances—toward the vent, producing as a consequence a coiled gut. As a further consequence of this upward migration of the mouth and the concentration of the intestinal tract and other major organs in the uppermost portion of the body, the animal becomes pear-shaped. Then the mosaic encasing of the body with polygonal plates took place, affording the much-needed protection to the sessile creature. And it is now that the echinoderm may be said to be well on its way.

As a matter of fact, fossils have been found that bear a very close resemblance to this pictured pear-shaped ancestor of the serpent-star. And it is partly from this fact that full confidence in the likeness of the portrait is possible. The further development of the group presents a more serious problem; it is unfortunately difficult to follow whether by the road of embryology or paleontology. It may be readily conceived, however, that the free-moving modern forms originally departed from this primitive type because of its eventual distribution to the shallower areas near the shore. Here wave-action would dislodge and tumble the individuals about; the best fitted to survive in this newer environment were those types amenable to modification; the rest became extinct. Some of these survivors, such as the holothurians, or sea-cucumbers, adapted themselves by digging into the substratum, while others, like the asteroids and echinoids, that is, the starfishes and sea-urchins, developed devices for clinging fast to the bottom, where still others, the ophiurans, to which our serpent-star belongs, became swimmers and therefore were able to retreat in time of storm or other stress. The crinoids, of course—the sea-lilies, those graceful faunal flowers of the deep sea—still remain attached in the probable birthplace of the group.

III

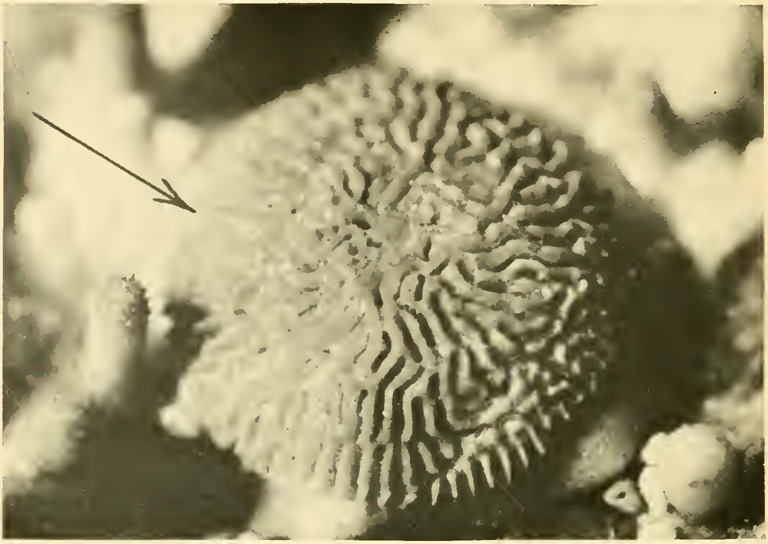
In a few days following the discovery of the larvæ in the dark-room tank, as I have recorded in Chapter II, I was also fortunate in securing some freshly spawned eggs. By keeping these in small flat-bottomed, shallow, glass-covered dishes, and changing the water each day, I had reasonable expectations of keeping enough of them alive until they passed through the complete metamorphosis by which they attain the adult form. Further to facilitate matters, I distributed their numbers among enough containers to avoid over-crowding; in each vessel the eggs were so strewn that they were amply separated as they rested on the bottom. They were kept on the bench along the windows, but not in the direct light of the sun. I also hoped, besides seeing for myself and for the first time the different stages of development, to obtain some light on another problem which arose. This pertained to their peculiar identity with the sea. No other group of animals is so restricted. Was there in the echinoderm constitution some fundamental feature that required it forever to remain in a habitat strictly marine, that prohibited it perpetually even from the fresh-waters of the land? It would seem that there was. Something I had seen in the larvæ swimming in the dark-room tank appeared partly to supply an answer.

Of the hundred strictly embryological observations that the course of my laboratory work has required, not one has ever palled on me. Never yet have I become wearied with the routine of watching those apparently simple changes taking place in the beginning organism; and doubtless I never shall. I know of nothing in the whole range of my activities that to me is more impressive, more profound than the dividing cells of a fertilized egg. For here one has to do with the very fundamentals of life itself; here one passes all outposts of laboratory research and stands at the actual frontier of the Unknowable; here, in short, arise those unan-

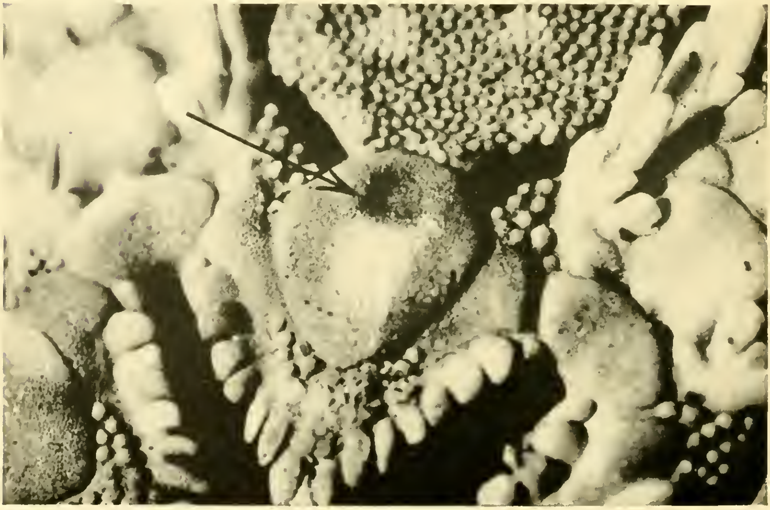

Primitive Dipleurula
Primitive Pelmatozoon
Primitive Aristocystis
D. aculeata, Young Larva
D. aculeata, Old Larva
THE SEA-LILY

ECHINODERMS

WILLIAM CROWDER



MADREPORITE OF THE COMMON STARFISH
Enlarged twenty times



MADREPORITE OF THE SERPENT STAR
Enlarged twenty-five times

swerable questions that confront every naturalist when he attempts to fathom to the utmost depths the meaning of what he sees.

This question of what constitutes the guiding principal of embryological development that correlates its complex phenomena and directs them to a definite end has baffled minds far more competent to cope with them than is mine; so I do not intend to tackle it. However, one cannot long witness these phenomena and escape the conclusion that there is a special mechanism involved, behind which is a power transmitted to the structure of the germ-plasm by foregoing generations. But the nature of this power and structure eludes analysis. And it appears that their determination will be long delayed; for as yet we know little or nothing of how the chemico-physical properties of hydrogen and oxygen involve those of even such a seemingly simple substance as water.

From one of the freshly stocked tumblers on my bench, I selected, with the aid of a glass dipping-tube, several tiny dark spherical dots—each slightly smaller than the period that ends this sentence—from among the numbers of other eggs that stippled the bottom, and transferred them to a watch crystal containing some sea-water. Obviously they had just been fertilized, for one was describing erratic circumscribed movements which, I readily guessed, was owing to the presence of the invisible spermatozoa whose impinging contact was causing it to rotate. The microscope soon confirmed this.

Under a lens of moderate power, the individual egg is seen to consist of a somewhat opaque, rufous yolk surrounded by a thick transparent shell. Near the surface of the yolk is a small round clear spot: the germinative vesicle, so called because it is this region that the single spermatozoön must penetrate to form that union from which the development of the future serpent-star proceeds. For of all the multitude of minute spermatozoa that are attracted to the proportionately vastly larger egg, only one is favored to come into coalescing contact with this spot fraught with such tremendous potentiality.

The spermatozoa were thickly clustered around the egg, and the majority of them, on inspection with a lens of still higher magnification, seemed to have their heads attached to, if not actually imbedded in the shell, while their tails continued in motion. These spermatozoa were somewhat like little transparent tadpoles, except that their highly hyaline heads were rounded, and their tails extremely slender and drawn out to considerable length.

Not many minutes after the penetration of a lucky spermatozoön, the germinal spot vanished, the yolk began to form a furrow completely around its periphery, and as a consequence the egg commenced to lose its spherical shape and achieved a symmetrical one distinguished by distinct halves.

The furrow rapidly deepened, and soon the egg divided into two equal and similar parts, at the same time disclosing a central transparent body within each spherule. The segmentation of the egg continued: the primary halves divided by a constriction forming on a plane transverse to the original plane of separation, thus forming four units; the quartet in turn divided likewise to form an octet, and this process of division was repeated until I could no longer trace the continuity or count the number of the cells. All remained contiguous and flattened against one another.

Now these repeated divisions, besides increasing the number and diminishing the size of the cells, presented another singular series of changes which may be well worth mentioning here. These changes concern the central transparent body within each cell, properly called the "nucleus." Regardless of in whatever light one may view the quidditative force that urges onward this peculiarly mystifying process of cell-division, the machinery through which it operates is manifest. In every instance the division of the cells was previously announced by the behavior of this significant component. It became altered in appearance and finally dissolved from view to occur again only when division was completed, itself now divided into two and each half occupying a new-formed cell.

Ten hours after the time of fertilization, examination of the serpent-star eggs showed that they consisted of a spherical aggregation of compressed cells, each containing a nucleus, surrounding a hollow interior. The eggs were still invested with their original membranous shells.

But now came a complete and striking change. And it is here that our echinoderm forges its first links in that chain of embryological evidence which so convincingly secures it to our *Dipleurula* of the past. A dent began to form on one side of the round egg; the first definite sign that it had ceased really to be an egg; it was now in the gastrula stage, a beginning larva. As the dent grew deeper, the invagination thus formed finally connected with the hollow interior, making what was later to be the mouth to the primitive digestive cavity. The outer surface of the gastrula now became covered with cilia, and the larva escaping from its egg-shell swam to the surface of the water.

Three days later, a look at my larvæ showed that they had elongated considerably; when seen from the side they were roughly triangular; when viewed from above they were somewhat boat-shaped but blunt at the ends. Underneath, they carried a keel, not in the usual fore and aft direction, but transversely, from beam to beam. This keel or ridge was fixed well aft, while immediately following it was the mouth, now apparently traveling toward the stern. Here it was that I first noticed that a spicular skeleton was starting to form.

It was the forming of this skeleton that decided me to experiment and try for an answer to the problem of their unique distinction among the animals of the world. How that problem was answered, I will show. But what should also become obvious is that in the showing, the answer to another equally pretty problem is presented. I have already given more than a hint that the internal conditions of the embryo's development are inherent and inherited. But development is also conditioned by external environment. In fact, every living thing throughout the entire period of its life reacts to its environment by certain changes in its physiological functions or its form. The embryo, like the adult, is an active balanced product, a product of the response of the inherited organization to the external conditions influencing its development. Therefore, it is patent that this development can be altered if the conditions are changed.

This I strove to do by raising some of my embryos in artificial sea-water containing no lime-salts. The change to this deficient medium proved to be too much for the majority of them; however, a few hardy ones survived, and these I nursed along with rare and keen solicitude. My considerate care was amply rewarded. For behold the result! the later larvæ failed to grow not only their covering of cilia, except around the mouth, but also their spicular skeletons; while their bodies remained stinted in substance, and their forms became urn-like, completely aborted in shape.

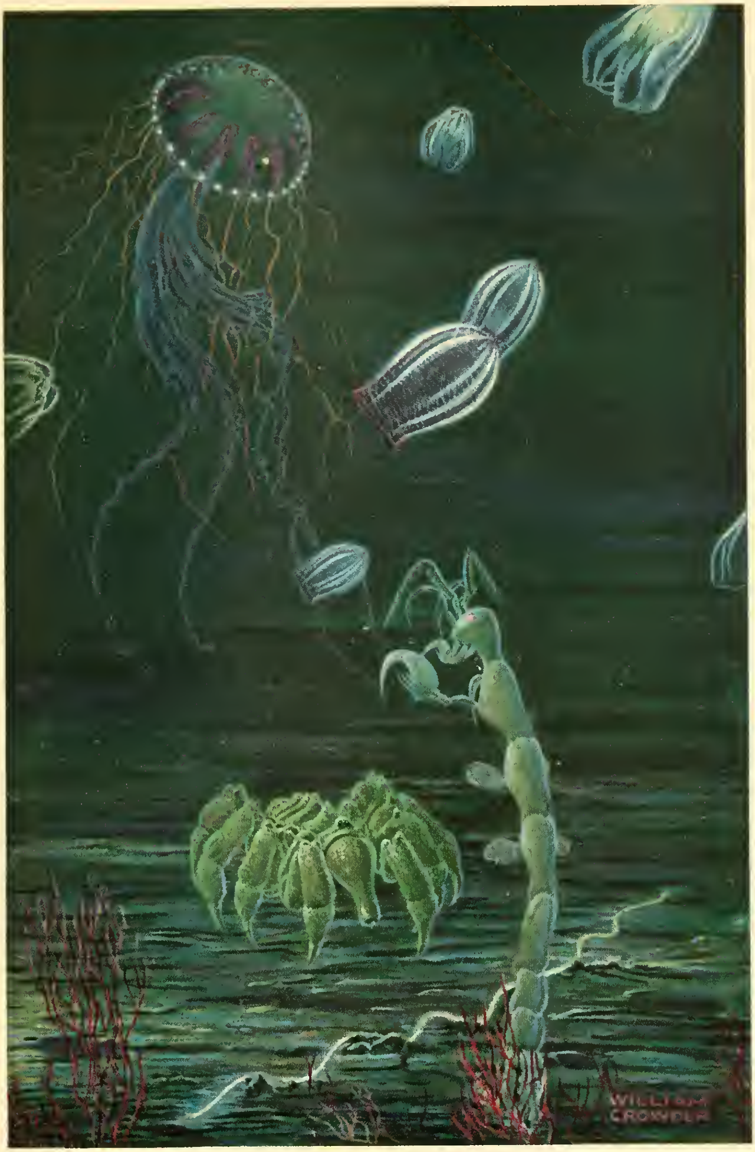
Now, strange to say, these odd abortions were in some respects nearer to a resemblance of the ancient echinoderm type than the normal larvæ: the mouth was near the end, or pole; likewise was the fringe of cilia, which hair-like processes were the only sensory organs retained. Nor would the urn-shaped body require much further modification to liken it to a pear.

Here was a devastating discovery! A previously conceived opinion which I had formed was rudely shattered. I shall not deny that I had to some extent foreseen the result of rearing the larval serpent-stars in water without lime-salts; that is to say, I anticipated that no skeletal structure would be formed. And I had held that fresh-water was inimical to the development of the entire group because of its insufficiency in these needed compounds. If this could be shown in the present experiment, what proof could be more convincing that my theory was indeed a fact? It is true, they lost their modern aspect, but they regained their ancient guise. Briefly then, fresh-water was a barrier seemingly only to the progress of the higher form; however, in the case of the primitive type, it offered no obstacle to growth, but actually appeared to foster it.

This puzzling paradox seemed hopelessly involved and utterly without explanation when, like a flare in the night, there flashed upon my full consciousness certain statistics, memorized long ago and which were until that moment still smoldering somewhere in the recesses of my brain: The age of the ocean, since the earth assumed its present form, is presumed to be somewhat less than 100,000,000 years. It is known that there exists at present, in solution in the sea, 4,800,000 cubic miles of salts; more than enough to cover the surface of the United States one and one-half miles deep. It is further known that the sea receives from the land, in addition to other elements, more than 60,000,000 tons of sodium every year. This substance, dissolved out of the rocks by rains and carried in solution by rivers and underground streams to the ocean, there combines with chlorine, and this chemical union forms the salt of the sea. Consequently, as we go farther and farther back

GHOSTS AND HOBGOBLINS OF THE SEA

Bolina: a comb-jelly (top-right)
Dactylometra: a scyphomedusa (upper-left)
Idyia: a comb-jelly (upper-middle)
Caprella: a skeleton-shrimp (middle-right)
Pycnogonum: a sea-spider (lower-middle)
Lumbriconereis: a phosphorescent worm (bottom-middle)


WILLIAM CROWDER

GHOSTS AND HOBGOBLINS OF THE SEA

in time, we can see how the primordial waters would become rarer and rarer in those earth-derived elements that compose the content of the present existing sea. Conversely, so to say, the ocean became saltier with each succeeding age . . . What plainer proof could my experiment give to establish the fresh-water ancestry of the serpent-star? Is it not more than extremely probable that the echinoderms having had their beginning in a deep and relatively saltless sea, and bearing the impress of the passing ages in their increasingly saline environment have so completely conformed to their marine habitat, in structure and the chemistry of their growth, that it has marked them forever as its very own?

If further proof were necessary to establish that it is because of chemical properties in the water that the echinoderms have become identified only with the sea, I should need merely to add that a slight excess of the necessary material is as profound in its influence as is a deficiency. Similar structural results to the experiment that I have just reviewed, can be achieved by adding a trace of potassium chloride to sea-water containing the normal amount of lime.

So the real wonder of the serpent-star's existence is not that it has gone no further in its evolution, but that it has gone as far on the road as it now is.

IV

Although the young of my serpent-stars have sufficiently served the purpose I have set about to accomplish, I shall not leave the interested reader in ignorance of their future development. Moreover, I think they have something to offer that will well repay our consideration.

Returning then to a period about a fortnight after the fertilization of the eggs, we find that the *plutei*, or free-swimming larvæ, have formed. They looked like—but how can I describe them? Perhaps the best way I can describe them is to say that they looked exactly like nothing else in the world but others of the same kind.

Now I am going to attempt a most unusual method of description; I am going to request of the reader that he on his part aid in the attempt. If he will first hold his either hand before him with the palm toward his face, and next bring the tip of the thumb over to the base of the little finger, tilting then the index finger and the little finger toward himself, meanwhile separating slightly the third and fourth digits, he will gain an idea from his hand above the wrist, of the approximate appearance of the larval outline. The mouth of our creature would be indicated by the space between the first joint of the thumb and the palm, as seen from above.

That is to say, the mouths of my free-swimming larvæ were now at the top, considerably removed from their original location in the early embryos. Their bodies are no longer ciliated over the entire surface, but a row of these rapidly vibrating lashes extends along each of the four finger-like extensions surrounding their mouths. These extensions are supported by projections of the spicular skeleton, which in this stage has become quite complex.

A few days later other extensions had grown around the mouth, and my larvæ had increased to such size that their individual movements could easily be watched with the unaided eye. Here and there they swam, near the surface film of the water, seeking the invisible notes of organic material that served them as food.

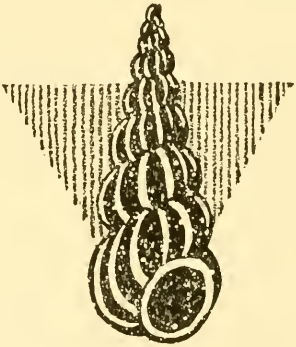
Then, shortly after, almost overnight, so it seemed, came a change in their behavior. No longer were they attracted to the brighter sides of the tanks; gradually their numbers ceased to frequent the surface; finally all but a few stragglers slunk to the bottom and hovered in the regions more remote from the light.

Examination now showed that many of them had formed on the side of their bodies five budding prominences, while in others, more advanced, these buds were augmented and formed a pretty rosette. As the hours passed, each rosette enlarged, the pluteus body meanwhile diminishing in substance and size. Soon all trace of the larva was gone; the rosette remained, but now the flower-like figure of each individual unit had changed to an asteroid: in my little laboratory universe, a new star was born . . .

It seems singularly in keeping with my thoughts as I set down these last lines, that in looking up through the semi-darkness of the room into the warm and brilliant night, I see a falling meteor streak its course across the skylight. But to me it is other than a fiery fragment of space, it is a symbol of that awful alchemy which by the same universal formula contrives the hatching of a serpent-star's egg and the birth of that expiring wanderer's parent sun.

I suppose that I am as emotionally responsive to the sight of the scintillant midnight heavens as are other average humans. Yet, in that vast panorama of tremendous beauty, wherein all is scaled in magnitudes that the mind is powerless to grasp, and therefore beholds only with admiration and dismay, I see nothing therein that is intrinsically more wonderful than in the microcosm on my work-bench. Surely, in the last analysis, Nature is not less ingenious in the molding of a larva than in the modeling of a planet. Let the poets and the philosophers have the heavens for their sentimental transcendencies; I am content to thrill over the Riddle of Existence as I contemplate the orbit of a polar body within a single cell. For here, also, superlatives may abound. Here are the infinitely beautiful, the infinitely little, and the infinitely near. And for me it holds another attraction greater still; it is the one enchantment that holds me spellbound to the microscope long hours after my enthusiastic wonder at other aspects of the cell has waned. It is Life. Of all manifestations of matter it is the most beautiful, the most mysterious, the most wonderful. Yes, and when a million, billion, trillion universes shall have come and gone, there will not in the end have been evolved a grander goal; the last world will contain no greater marvel than was the first living cell . . .

So my shooting-star seems to become more than symbolic of origins. It connotes a concept in which the forming of a system of suns is of an inferior order to the production of that vital spark within the egg of our serpent-star.



CHAPTER FOUR

An Adventure in the Microcosm

I

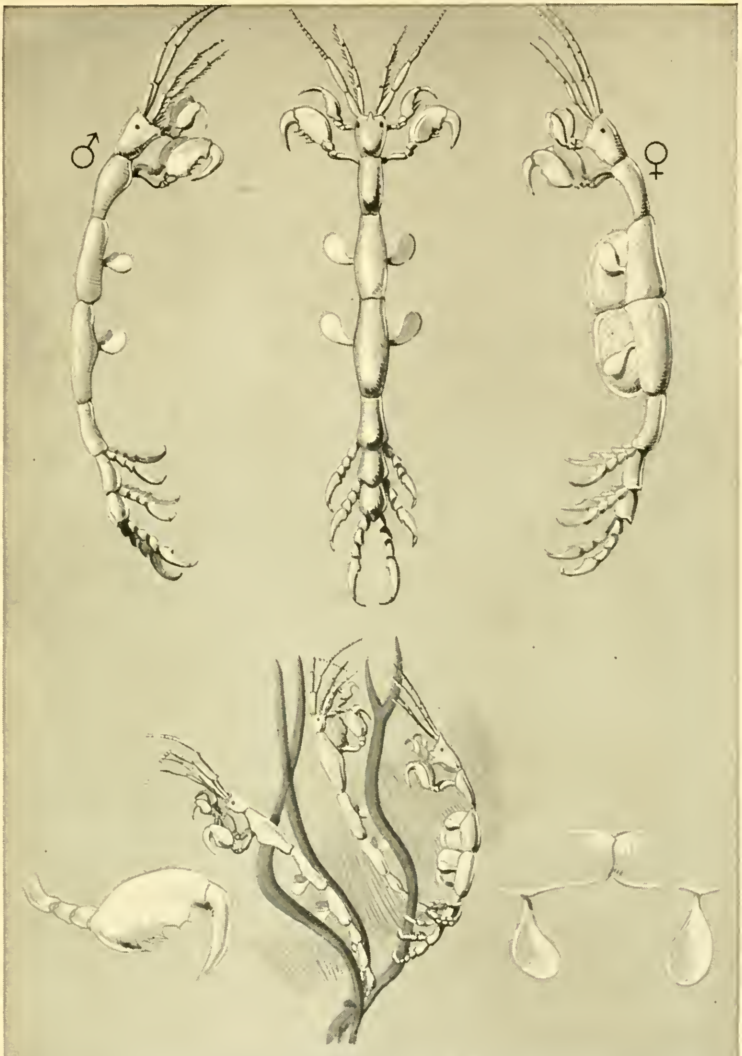
IT would seem that to a naturalist, the tools of his trade would be about his last resort for moments of diversion. It would seem, also, that with his multifarious employments, he should need no diversion—judging from the amount of nonsense that appears in print pertaining to the deep and exclusive devotion with which he continuously prosecutes his work.

But do not be deceived. Without wishing for an instant to have it appear that the fascination of natural history ever fails, I should hardly be candid were I to attempt to conceal that there come times when he tires mentally and physically from the wearisome routine of certain phases of his occupation, or from exhausting vigils to verify by actual observation what oftentimes he knows in advance will be the inevitable result.

Then it is, after these long hours engaged in his labor of love, livelihood, or science, he seeks relief in play; then it is, he turns for amusement to his microscope. The microscope then ceases to be an instrument of research; it becomes a toy, an imaginary means of transport whereupon he rides to revel in a fairyland. But his is a fairyland of realities. It is a veritable playground peopled with forms more fantastic than are found in any extravagancies of fiction. It is the scene of a gorgeous pageantry in which the paraders are reviewed in fact, and not in fancy, as ogres, hobgoblins, pretty patterned masqueraders, and living jewels of the sea.

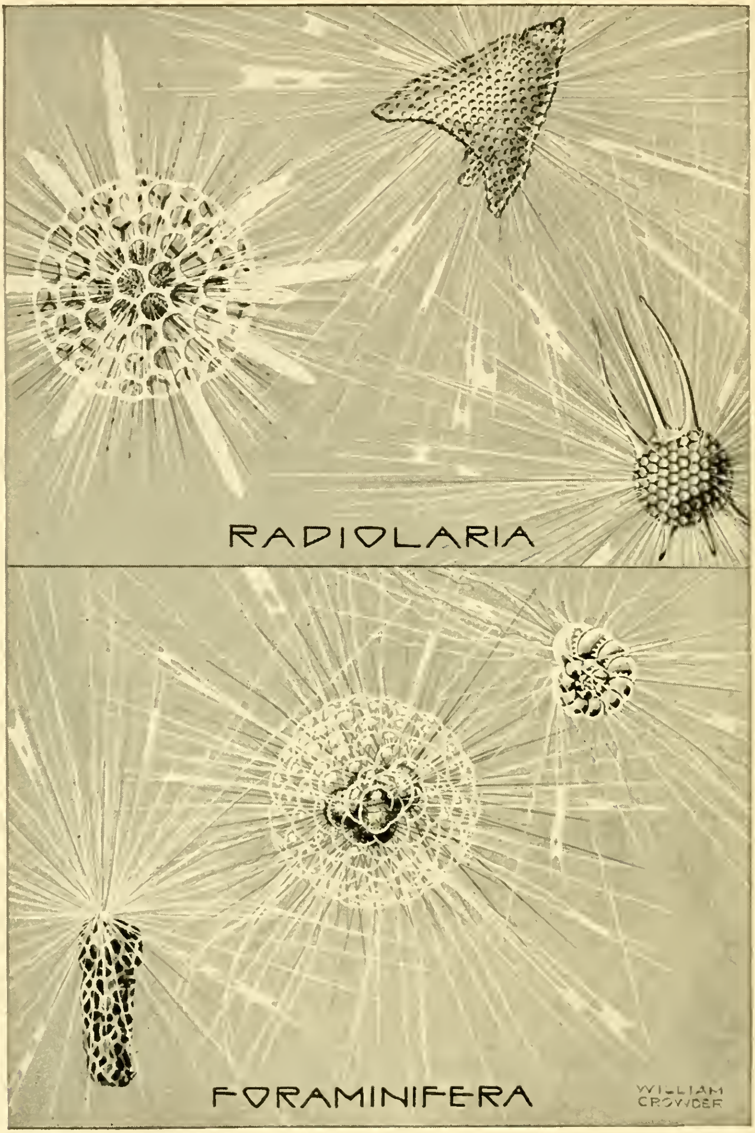
To-night, such a situation is at hand. I am determined to abandon serious work for the present, and to find some leisure in the mystic microcosm just mentioned. But I shall share my pastime with the reader, so that he, too, may find relief; it will, therefore give us both a rest from the more exacting subtleties of natural science.

What shall I look at first? . . . Beside me stands a case of shallow drawers containing hundreds of classified prepared microscope slides. The variety of subjects is almost endless; they range



THE SKELETON SHRIMP

WILLIAM CROWDER


RADIOLARIA
FORAMINIFERA
WILLIAM CROWDER

from single-celled marine plants and animals to serial sections of chordate embryos. A random selection is almost sure to reveal some likely subject; for none is without interest; but now we are concerned with what meets the eye, rather than the mind. Here is a drawer bearing on its front the word *Protista*—a name given to the group of one-celled beings which, according to the taxonomists, are in many instances neither distinctly plants nor animals, but often betray the characteristics of both, belonging, so to speak, to the borderland. But as some undoubted plants and animals have been found in this debatable region, the name now stands as a synonym for all adult organisms consisting of a single cell regardless of its kind. Let us glance at some of these.

Passing over those mounts in the A's which include that protozoön, often mistakenly celebrated as the lowest form of life, the ameba, and over the B's bearing the bacteria which *are* the most probable candidates for that doubtful honor, and over the C's containing those curious crescent-shaped plants, closteria, I come to section D. From here I abstract one of the thin glass slips which has a label denoting it as a mount of *Dinoflagellata*, one of the many groups of minuscules which at night-time impart a phosphorescent aspect to the sea.

Under the microscope, on a dark field, their nearly transparent bodies reflect many delicate colors. As if in the manner of a kaleidoscope, when I shift but slightly the position of the slide, the colors change, dissolving into other, yet equally delightful tints. Mere words, of course, are utterly useless in any effort to convey the likeness of these prismatic irradiations. Nor would pigments be any better. To visualize for others such sorceries of color, one must acquire something more than a knowledge of the palette: one must learn the secret of fixing to his canvas the luminous essence of the rainbow, or of phantom-fire.

The slide is strewn with various species. Near the edge of the circular field is one form which at first sight resembles a many-hooped cask; but more careful inspection reveals that the places of the hoops are really depressions engirdling the animal. Lying in each depression can be seen a long, hair-like lash. On one side of the creature a deep groove runs along the whole length of its body; within this groove lies another lash, longer and thicker than the others, which in life is whipped about in the water, thus functioning as a propeller or oar. Among the *Dinoflagellata* none bears a popular name; but for the benefit of the curious, I will give the one that science has devised for this particular form, *Polykrikos schwarzi*—a mongrel mouthful meaning "many rings." A more musical term, however, is *Ceratium reticulatum*, which graces another individual near-by; but except for the sameness of its surface texture, it would never be suspected by the amateur microscopist as one of the crowd. In keeping with its title it is truly a "horned network." It is a rounded, basket-like affair having on opposite sides at the rim a pair of great horns, somewhat curved, bearing a resemblance to those of a bull. A third horn, greater still, projects straight from the bottom of the basket. And now, situated almost in the center of the slide, comes *Noctiluca;* easily the simplest in form, if not the greatest in size, of all the three hundred or more different *Dinoflagellata* that dwell in the so-called seven seas.

It is due chiefly to certain species of *Dinoflagellata* that the sea not only becomes phosphorescent at night, but also oftentimes assumes a deep and brilliant tinge of red by day. The amazing spectacle of phosphorescence is produced by many various forms of these animals, but the commonest light-producers of all are the species of *Noctiluca.*

Actually, they are not often larger in diameter than a pencil dot; but the species *Noctiluca miliaris* now magnified under the lens of my microscope looms up as large as an apple. And not greatly unlike an apple is it in general; what stands for the stem is in *Noctiluca* a long pointed process resembling a heavy lash. At the base of this lash, or flagellum, is the mouth, a groove-like orifice reaching nearly half-way around one side. From the mouth extrudes a much smaller and finer hair-like organ, the second flagellum. As in the case of all other *Dinoflagellata*, in life it swims with the help of the large flagellum; the smaller flagellum it uses to capture food. Though *Noctiluca* consists of but a single cell, it lives and eats in the manner of its larger neighbors in the sea whose bodies are composed of a billion or more; despite its minuteness and simple structure it preys upon other organisms still smaller, and is seemingly able readily to detect by the merest touch the difference between that food which is edible and that which is not.

Further to dwell on the *Dinoflagellata* would be interesting; much could be detailed regarding the peculiar properties of their "cold" and phosphorescent light; a chapter could scarce contain all that might be said about their achievement of immortality, wherein the adults never die a "natural" death but translate their identity by dividing into daughter twins; nor would their haunts and habits fail to hold our attention for a while; but our notice of *Noctiluca* and others of its kind must necessarily be brief, for I have still other slides to see.

Also in the D section come the diatoms. Unlike the slide I have just considered, the one now selected fails under the most careful scrutiny to disclose anything to the unaided sight. The circular area occupied by the cover-glass under which the objects are cemented to the slide, has every appearance of being nothing else than the most transparent glass. And yet within the diameter of this circle, the diameter of which does not exceed a fourth of an inch, there are loosely dispersed more than five thousand individual frustules, or silicious skeletons of *Pluurosigma angulatum*, which is the particular species of diatom we are presently to observe.

There are hundreds of different forms of minute one-celled plants in the sea, but the diatoms are distinguished among them as being the only ones having their soft vegetative parts contained in an outside covering, or case, of silica. It is by the shape and sculpturing of this exterior glass-like skeleton that the species are identified. Twelve thousand or more species have already been named and recorded; this imposing list, which is constantly being extended, is not due so much to the scientific interest they hold for the "students" of the group, as it is owing to their attraction for those microscopists who have made the collecting of them a fatuous, perhaps, but harmless hobby. It may seem incredible, but there have been diatomaniacs who have devoted their lives to the tracking and mounting of these generally invisible motes; they have become so adroit in manipulating them under the lens that the arrangement of several hundred different forms in orderly and geometric patterns is produced on a single slide with the same precision that attends the efforts of a chess player when he adjusts the pieces on his board.

Diatoms, of course, are not peculiar to the sea alone: they occur also on moist rocks and soil, in fresh-water streams and ponds, and on the surface of perennial mud. Marine forms are sometimes attached to seaweeds, and many forms are often found in the stomachs of clams and sea-squirts and other animals that siphon their food from the water; but by far the greatest number are those that float independently, free. Each individual, or frustule, is composed of two valves, the silicious covering, or skeletal case, structurally not unlike an ordinary pill-box. That is to say, one half of the case is slightly larger than the other and fits over it like a cover. One peculiarity of the living diatom, which is likely to strike the observer's first notice, is its extraordinary power of motion. Some species move slowly to and fro in a straight line; others are relatively rapid, leaping or darting around erratically or sometimes following a zigzag course in the water. The cause of this motion has never definitely been determined; but speculation has not been wanting to account for it. The most probable theory is that which supposes the diatom to exude a mucilaginous substance with such force as to propel itself through the water in the manner of a hydraulic submarine boat. Not only at the present time are these plants giving their quota to fresh-water and marine deposits, they have also in the past contributed quite an abundance. When the diatom dies, its silica shell sinks to the bottom of the water in which it lives, and there forms part of the sediment. The later hardening of this sediment into rock leaves the glassy frustules unaltered. Indeed, almost pure cultures of fossil diatoms, so to speak, exist in great tracts throughout the world. Perhaps the most remarkable is that of Richmond, Virginia; it is miles in area, and in many places it is more than forty feet in depth. Yet it is a noteworthy fact that the most ancient fossil diatoms found differ not in slightest essential degree from those living to-day. In truth, in most respects former genera and even species are like their modern representatives; most of them in the minutest detail are identical.

II

Our first view of the diatom *P. angulatum* under the lens and enlarged one hundred diameters reveals it as a flat sigmoid, or somewhat S-shaped object whose graceful curving lines taper from the middle region—its greatest breadth—to a point at both ends. It is seven times as long as it is wide, and throughout its length runs a middle longitudinal line, or rib (the raphe) relieved only at the central region of the test by a navel-like enlargement. At this magnification it looks not much larger than a wasp's wing, to which it may aptly be compared—so gauzy and transparent is this fragile tenement of the microscopic plant. Measuring it, however, with a micrometric eyepiece, we find its actual size over all to be exactly one thousandth of an inch.

Such is the short and easy, though complete, description of the form and size of this diatom as seen with a low-power lens. But how can one describe that caress of carmine, now becoming a radiant rose, now going into the greens, now grading into azure and deep mauve as the frustule, viewed by reflected light, is variously oriented over a background of solid black! Again, as when we looked at the *Dinoflagellata*, we are met with a marvel of color that is positively unutterable. However, unlike the display of the *Dinoflagellata*, in which many hues were simultaneously visible, our diatom presents its spectrum tints successively and in monochrome.

In truth these are pure spectrum shades; which is to say, they are due to diffraction; the frustules, having the same power as has a prism or the grating of the spectroscope, split up the rays of received "white" light and pass onward the beams in their primary colors. The peculiarity in the structure of *P. angulatum* that causes this phenomenon is one which the present magnification cannot reveal; so let us inquire with a lens of higher power.

Dispensing now with a dark background and viewing the diatom by transmitted light, that is, with the light passing straight through the object, we behold in the place of a number of smaller individuals on the slide, but a single specimen extending clear across the illuminated circular field. So close have we come to our subject at five hundred diameters enlargement that there is room for only one within the range of the constant circle of light. But even at this magnification a sharp eye is necessary immediately to detect any change. It should become apparent, nevertheless, that the silicious case is not of a smooth unbroken texture: it is, in fact, marked on each side of the middle rib, over its entire face, with minute striæ, straight cross-hatched lines having the aspect of an exquisitely fine screen.

Yet this is not all. This screen-like sculpturing is of a kind that is deserving of still further scrutiny. And for that purpose we are now obliged to resort to that last word in the optics of microscopy, the oil-immersion objective lens.

In reference to the use of this highly technical tool, a brief preliminary explanation should be made.

The modern microscope, like the modern motor of the automobile or airplane, because of its many mechanical appurtenances and other external features for refining its operation, appears to the uninformed as a complex and imposing thing. Fundamentally, however, it is simplicity itself. Nor are the principles involved in the theory and practice of its optics less simple. Reduced to its barest parts, the microscope consists merely of a tube containing two lens systems—one system at the upper end of the tube, called the eyepiece; one system at the lower end, the objective. As it is the quality, or *resolution*, of the image rather than mere magnification, *per se*, that concerns the microscopist, it becomes obvious that the objective is the most vital part of the instrument. For on its performance in giving sharp distinction to extremely minute structural details, depends the eyepiece; the latter lens system acts only further to magnify, and not resolve, the image already formed. In other words, if either a sequence of fine lines or an assemblage of dots whose diameters, and whose distances apart, are no greater than, say, 3/250,000 of an inch, are viewed with an objective of high magnifying power but poor resolving properties, the resulting image will be but a blur; conversely, a good lens comparatively lower in power, will separate these dots and lines causing them to stand out distinct and clear. Therefore, the limits to which magnification may be carried are infinite; but beyond certain points their attainment would be worthless, for, unfortunately, the resolving power of lenses is fixed by certain physical factors which have to do with the nature of the glass with which they are constructed and the amount of light they can transmit.

Even the ultra-microscope, which has recently come to the fore, is subject to the same restraints. It gets around the difficulties of resolution not by an improvement in the lens so much as in utilizing an improved kind or quality of light. Its capacity for magnification is no greater than its predecessors', but its interpretations are more profound. Notwithstanding that it reveals a light-effect rather than an actual image, one reads by the help of its rays messages from the microcosm, undecipherable by any other means.

Without question, lenses of greater resolution than at present prevail are much to be desired. Yet the fact remains that however much we resolve or magnify, however far we penetrate these mysterious microcosmic labyrinths, there will always be still further regions remaining to be explored, and even beyond these will lie others without end. None the less, for the ordinary worker, modern lenses meet most requirements. Indeed, except when pursuing a very special line of research, the naturalist employs in the greater part of his work relatively rather low powers.

Now, as I have indicated, we have in the oil-immersion lens a tool well worthy of our present investigation of diatom structure. The oil-immersion lens differs from the so-called "dry" lens in that its higher magnifying power is combined with remarkable resolving properties. This latter, however, is achieved in a rather peculiar way: only when a drop of cedar oil (or similar substitute) is applied to fill the extremely small space which exists between the lens and the object.

Let me explain. As lenses increase in magnifying power, they decrease in physical dimensions. Consequently, in the oil-immersion objective the effective aperture of the front lens is little more than a thirty-second of an inch in diameter. Ordinary white light being radiated from an object equally in all directions, it is evident that the more rays collected by the lens, the more distinct will be the image. Thus the aperture of a lens, in relation to its distance from the object, determines the quality of definition. But there is another feature which has a very important bearing on the question of the effectiveness of the oil-immersion lens. We know that, according to the laws of refraction, as the light rays leave an object, if the medium through which they pass becomes more dense, the divergent rays become more bent—that is, the refraction becomes greater. So, cedar oil, happening to have the same refractive index, or density, as glass, the two by contact become virtually homogeneous, and no refraction takes place; the rays do not stray away, as they would in air, but are passed without loss direct through the lens.

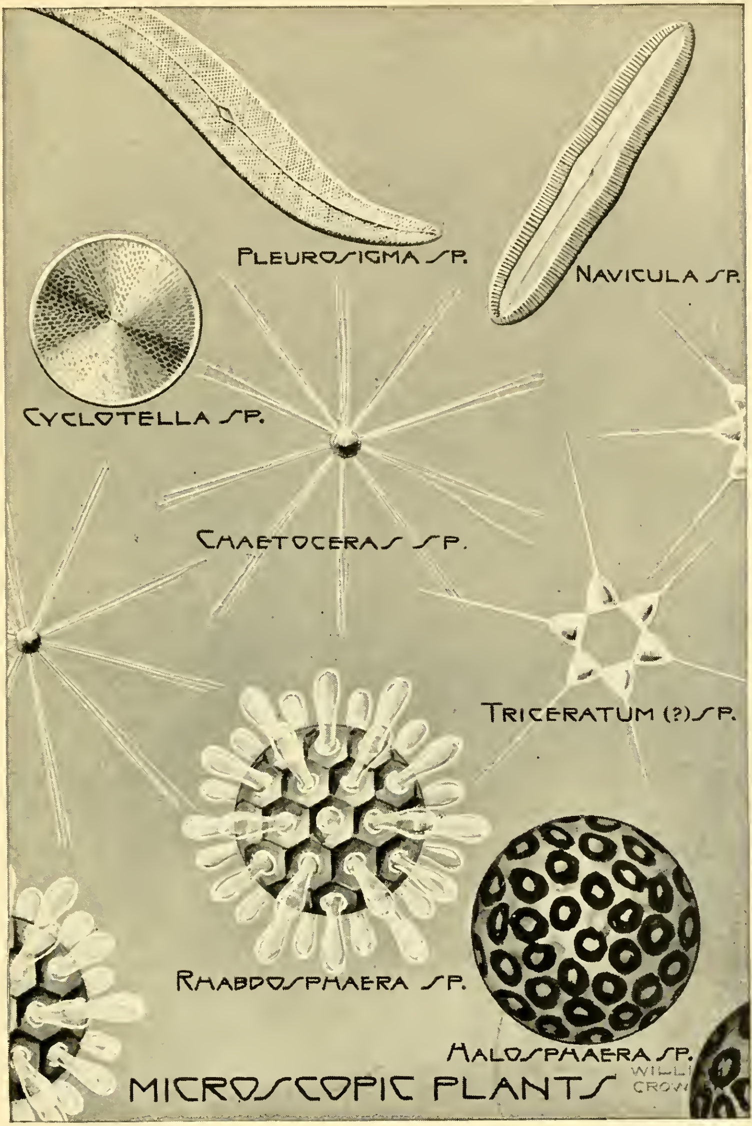
In passing, let me point out, there is no production of the human hand that is more delicate, none which must be so faultless as the objective lenses of the compound microscope. In the finer processes of their manufacture, all mechanical measurements fail, and recourse must be had to highly sensitive optical tests to determine errors.

And here again our diatom deserves distinction of a kind. For it has been of inestimable aid to lens makers in the perfection they have already achieved; it is the minute markings of certain species—among which those of *P. angulatum* serve exceedingly well—that they use to test the properties of their lenses.

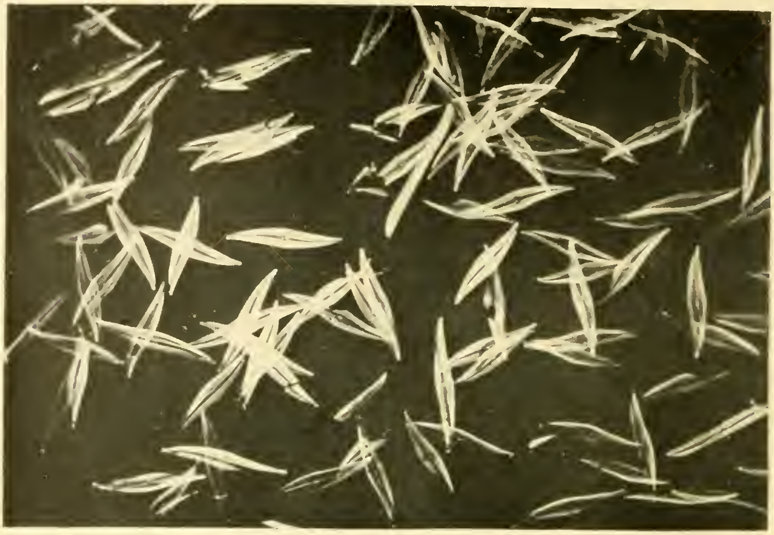
If I have gone into this subject to some extent, it is because it would seem that, aside from specialists and others who regularly use this instrument in their work, there exists a general ignorance regarding its capacity and possibilities for common enjoyment. It is quite probable that if the microscope were to be cultivated by the majority solely as a diversion, not only would it afford relaxation and pleasure, but it would also develop among keen amateurs another Fabre, perhaps, or a Huxley, or an Agassiz.

Let us now take our last look at P. *angulatum.*

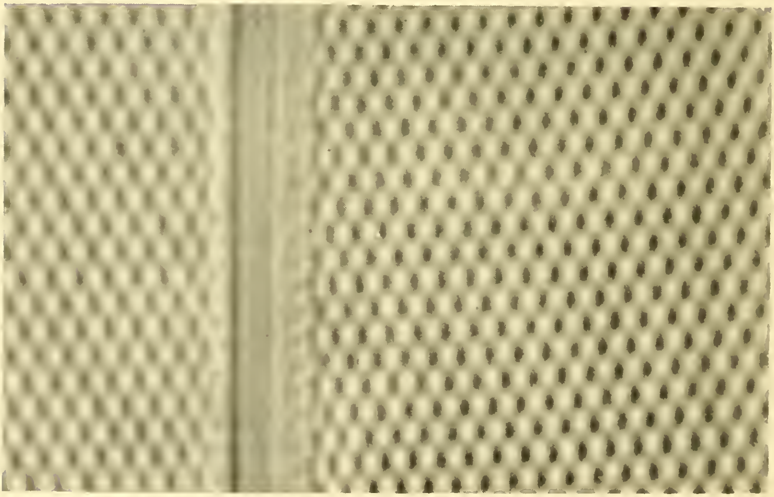
We have seen how this diatom, at a magnification of five hundred diameters, under a dry lens, appeared as having a striated, or screen-like, sculpturing. Observe then, that the immersion lens, together with the proper eyepiece, presents not only a more highly magnified, but also a quite different picture of this pattern. As we now see it, magnified more than twelve hundred times, the lines, as such, have disappeared and instead there is resolved a succession of dots: the striæ in reality consist of a series of small circular cavities, or depressions, in the silicious shell. Arranged in orderly rows, the exquisite appearance of such minute and geometrically precise pips amazes the beholder. Consider. The entire diatom is so small as to be totally invisible to the ordinary eye. Still it is completely covered with sculpturings of round recesses so vastly smaller that when measured with a micrometer the diameter of these mark-


PLEUROSIGMA SP.
NAVICULA SP.
CYCLOTELLA SP.
CHAETOCERAS SP.
TRICERATUM (?) SP.
RHABDOSPHAERA SP.
HALOSPHAERA SP.
WILLI
CROW

MICROSCOPIC PLANTS



DIATOMS *Pleurosigma angulatum*
Magnified 50 diameters



Pleurosigma angulatum
Magnified 5,000 diameters

ings shows that it would take not many fewer than 50,000 to span an inch . . . And yet, compared with the markings of certain other species relatively common in Nature, the frustular dot-pattern of this diatom may well be regarded as coarse!

III

It would be possible, of course, to pursue for hours my inquiry among the protistan slides alone, without tiring or feeling impelled to seek the attractions among the other phyla of my case. But no single sitting could exhaust their wonders. An entire evening or more could easily be taken up with the beauties of even one group, such as the *Foraminifera* or, say, the *Radiolaria:* the first-named containing the *Globigerinidæ*, famous for their countless billions of dead skeletons which compose those great tracts of "Globigerina ooze" covering certain regions of the ocean floor; and the last-named preëminently beautiful among the creatures of the earth, and certainly the very loveliest of all protozoa.

Notwithstanding their attraction and their instructive features, the subjects contained in my case are at best but dead and inanimate things;

compared with the living forms, many of them are sadly wanting, indeed. It is as if an ordinary photograph were compared to a motion-picture in color. Particularly is this true of those extremely delicate organisms without a skeleton or hard parts. Where it is at all possible to preserve them as microscope mounts, the process of preparation oftentimes alters their shapes; always it destroys their colors. However, the dead mounted subject has one advantageous feature not shared by the living organism, which lends itself to the inquiry of the microscopist. Methods in microtechnique make it possible to clear opaque tissues; with the aid of selective stains—that is, with dyes which color certain parts, leaving the others transparent—important inner structures can be revealed; and not seldom these are as beautiful to the eye as they are significant to the mind.

Reluctantly, then, I leave the further allurements of the slide-case, and bring forth from its box on a shelf my low-power binocular microscope. Unlike its higher-powered brother, the monocular just abandoned, the binocular with its paired objective lenses is the only instrument allowing true stereoscopic vision. Everything within the range of focus stands out in strong plastic relief; with the monocular the image is flat. The general flexibility, also, of the binocular now makes it the instrument *par excellence* for the purpose at hand. So, setting it before a three-gallon glass tank filled with salt-water and the usual seaweeds, and containing no creatures more imposing to the casual glance than a couple of common green-crabs, I bring it to bear upon an empty oyster-shell half-imbedded in the gravel on the bottom. The powerful beam of my laboratory lamp is so fixed that its sharp circle of light—less than four inches in diameter—floods the shell with dazzling brightness. All other lights in the room are switched off; I settle into a chair before the illuminous shell, and in the outer darkness prepare for a cinema all my own.

I have not selected this shell without consideration. It is old and rotten. Its surface, once pitted over the greater part by the perforating solvent of a boring sponge, is now encrusted with the scurf of dead worm tubes and empty barnacle shells. The only visible signs which it betrays of inhabiting life are the inconspicuous, lace-like patch of calcareous film, covering the space of about a nail's-breadth near the rim of the shell and indicating the presence of a colony of polyzoa, or corallines, and a dwarfed form of some red seaweed which seemingly in stubborn desperation still retains its foothold in the rotten relic. Throughout the exterior it is seamed and scored with the corrosion of time; and where the nacreous substance is exposed, it is darkened by decay. But I well know that it is in such unprepossessing precincts that many minute folk are wont to dwell.

My first peep through the binocular proves my convictions. Only a small portion of the whole area of the shell shows in the field of view; but within this space I see several gem-like creatures swarming over a miniature mountain of pearly pink then down into a ravine of delicate shimmering orange. Nor are the living jewels less delightful to the eye than their setting. They are so totally unlike anything of common experience that no comparison for descriptive purposes is possible. The most that can be intelligibly expressed, may be contained in the brief statement that they are entomostracans that remotely resemble in form that of the possibly distantly related horseshoe-crab. But here all likeness stops. No crab-like creature that can be seen with the naked eye is possessed of a body so transparent and yet so lustrous. It glitters with all the fiery colors of an opal. Equally striking is the single eye each individual carries at the forefront of its body; this is positively dazzling; it shines like a golden ball in the rays of the noonday sun . . .

Upon whatever business these cyclopean creatures are bent, it is hard to determine. Here and there, and to and fro, they skitter, stopping only for short intervals at the end of each excursion, seemingly having no other purpose than to explore the neighborhood. If they are finding food, the act escapes me, as I am aware of nothing within sight that they can eat. But they cut short my inquiry, presently, by abruptly disappearing, one after the other, into a black cavernous opening near the edge of the field.

With somewhat of the physical sensations of an aviator reconnoitering an unknown terrain, I prepare to make a survey of the entire landscape—moonscape would perhaps be the apter word, so like another planet is the view—when I am arrested by a Something which is stealthily emerging from the cavern at the side.

What seems to be a transparent and highly iridescent angle-worm slowly and cautiously reveals itself, meanwhile probing the surrounding medium at the large entrance to its retreat with deliberate and graceful contortions. Its emergence, however, is immediately followed by that of another, identical in appearance and behavior. Hesitatingly the twins insinuate the exposed portion of their bodies around the crags and into the crevices that mark the immediate vicinity as if making sure that no enemy is at hand to attack them when once they have withdrawn completely from their hiding place. Then, with a suddenness that causes me instinctively to recoil from the eyepieces, there appears from within the cave the forefront of a huge dragon-like beast, part and parcel of the worm-shaped twins which I now perceive to be only appendages. It is, in truth, a worm. But, if I may so express myself, it more nearly resembles a Chinese dragon than that monstrosity resembles itself. Beside the long appendages just described, which are tactile organs, or feelers, the head is adorned with three other and shorter pairs, giving the owner a visage uniquely grotesque. Nevertheless, this being, seemingly in compensation, is endowed with a body whose elegance and splendor somehow make one forget the nightmare which the details of its horned head recall. The several or more segments that it deigns to extend for my appraisal are really bewitching: a row of abutting soap bubbles, each bubble graced at the sides with a pair of great butterfly wings would be a passable picture of the general shape; but I doubt if that bubble has ever been blown which could diffract incident light in such variety and with such amplitude as are exhibited in these sheeny segments; surely, no butterfly wing offers such pleasing tints as these tenuous, translucent gill structures which in their constant wafting are alternately tinctured with a soft, incarnadine radiance and the purest azure . . . Nor are these all of its colorful attributes. Its beautiful body being quite transparent, one can see within it the beating of its very heart. With every systole and diastole there follows a delicate flush of crimson which spreads throughout the segments and finally dies away in the gauzy network of capillaries fringing the winglike gills.

With a sort of sensuous delight, I make an ocular feast upon this prepossessing monster while awaiting with rapturous anticipation until it leaves the lair, so that I may revel in sight of its entire being. But no farther does it extend itself; it remains for the most part poised, as it were, gently undulating in mid-air—mid-water seems not quite the truth, for through my magic lenses all realism is lost.

The illusion is not long-lasting, though; for suddenly all is darkness . . . No, not all: where formerly was my worm, there gradually resolves itself in faint outlines of greenish fire, its phantom form! . . .

During my complete absorption, I neglect my lamp, with the consequence that upon my chance encounter with the wires, a faulty connection is strained and the light goes out. At any rate, this is a most fortunate accident. It reveals the fact that my microscopic worm is phosphorescent.

With matters fixed, I resume my place at the binocular. But my pretty worm is gone. The only life now visible is the scintillating form of some creature as it curves across the field at a speed too great for me to make out its details. Therefore, I decide to move on.

Over hills of jasper veined with silver and gold, past valleys floored with crystals of amethyst, I rove in search of other wonders. Actually I am traveling at an imperceptible pace, although *apparently* my progress is swift. Under the lens, the rate of movement is magnified as well as is dimension. Skirting the base of the red seaweed clinging to the shell, and whose every cell is now conspicuous, resembling a combined curtain composed of aboriginal beadwork, I am shortly brought to a halt by what appears to be a tall circular chimney constructed of amorphous blocks of white marble and topaz and clear quartz. Obviously this is an artifact. Such pieces do not assemble themselves naturally in so exquisite and orderly a formation. Each component is fitted into place with a nicety not surpassed by examples of human handiwork.

A constant stream of suspended particles flowing into the orifice at the top betrays the presence of the artisan within. Motes drifting casually by when coming within the radius of several diameters of the hole suddenly disappear down the tube as if caught in the vortex of a whirlpool. Most of these motes, I perceive, are minute protozoa.

Now structures such as this, both microscopic and macroscopic, are not exactly new to me; and it is therefore easy to guess who is the builder. In the learned language of science it is known as a tubicolous polychæte annelid; but I am content to term it just a worm—for that is what it is, a tube-builder which bears bristles on its body.

The immediate cause of the miniature maelstrom now becomes apparent. A pair of vermiform feelers, each invested with an iridescent halo of brilliant blue, begins to deploy diffidently from the opening. This halo, or peculiar bright blur, is a ciliary effect; the minute hairs with which the feelers are covered vibrate so rapidly that the eye cannot follow their movements. And it is by their movements that the food-bearing currents in the water are produced. By this same process the animal also breathes: the currents that carry sustenance, bring fresh supplies of oxygen; so in a sense, it may be said that our worm fetches in its prey at a breath. The currents can also be reversed. Occasionally a particle of debris comes from within the tube and is carried outward, close along one of the feelers, seemingly transported over the tips of the moving invisible cilia. Like the worm I have just previously observed, this one appears unwilling to chance complete exposure without first finding out whether the coast is clear.

Hello! . . . I nearly missed that. A head glistening with spectral orange and fringed with saffron appendages appeared in the opening; quickly and with precision it placed a rough block of lapis lazuli on the rim, cemented it and disappeared . . . The operation was so swift and unexpected that I had no time to catch the details; but I have learned what patience will bring, so I determine to wait.

Again the opportunity comes. Not exactly sooner than expected; nevertheless it comes with a suddenness as marked as in the first instance. The worm reappears, sets its stone in a twinkling and is gone almost before I am aware of what is happening. Successive operations in this building business tell me no more. Always the material is deposited with such despatch that the eye is helpless; only a slow-motion camera could record its continuity. It is exasperating; none the less, its behavior is admirable. In the background of what passes for its thoughts, there is doubtless knowledge of a kind that any lingering over its task would invite almost certain death from the attack of one or more of the hundred enemies who are always lurking near. How and where this mason obtains its materials for the structural marvel in which it is permanently housed, would seem to be as difficult to determine as the manner of their deposition . . . But the reply to questions such as these is only to be got by work; to-night I intend merely to play; so I leave the worm and its problems to continue my excursion over the shell—but I leave not without the reservation that some day I will look more closely into this affair.

IV

I am hovering over a vast valley paved with perforated ovoid cobblestones having the color of pale-rose and the diaphaneity and texture of fine porcelain, and whose centers each bear a ghostly corolla of filamentous petals. The eerie feeling which this great garden of spectral flowers engenders is enhanced still more by the presence of three great eldritch forms rearing phantom-like from the valley floor . . . *Caprellidæ* . . .

Such, briefly, are the sight and sensation first conveyed by a close-up of the coralline patch previously alluded to during my superficial examination of the oyster-shell. In the magnification of the minute, one easily can forget the fact that these cobblestones are merely the calcareous shelters of living creatures, that the flowers are the tentacles of the animals within. Nor is it hard to give free reign to fancy when *Caprella*, the common skeleton-shrimp, comes under the lens, for then it turns into a veritable ogre. Indeed, such transformations are familiar to the microscope.

Soon, however, the purely emotional and artistic feelings which this nether-scene inspire, give way to one more pragmatic; I begin to note professionally an oddity in one of the *Caprellidæ*.

Two of the skeleton-shrimps are close together in the center of the field, standing upright with their hind legs hooked to a coralline and maintaining the grotesque posture peculiar to their kind; the third, similarly posed, is midway toward the edge. The latter is a female, and but for the big brood-pouch she bears on the front of her slender belly, her form is not unlike that of her male companions. All have curiously attenuated bodies encased in hard transparent armor. Except for their paired, black compound eyes, which glisten like tiny beads of jet, they are colorless. Their appendages are few, and some of these are atrophied. Nevertheless, this dearth is fully compensated for by their enormous claws. These claws are sickle-like and work on the principle of a folding jack-knife; and their possession of these extraordinary weapons, which are constantly poised in a threatening attitude, gives them an aspect of ferocity frightful to behold. Indeed, these hooks can be wielded with terrible efficiency or clamped with deadly effect upon their smaller prey.

Notwithstanding their popular name, *Caprellidæ* are not shrimps; they are amphipods, crustaceans which comprise among their members the larger and better-known sand-fleas of salt-water beaches. The three specimens I now behold are of the species *C. geometrica* and in length measure not much more than a quarter of an inch; in the microscope, however, they look like giants.

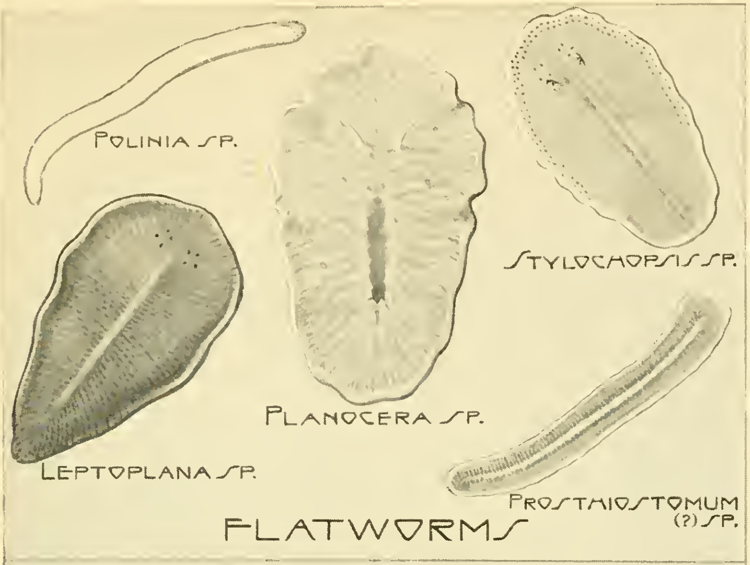
It is the female whose appearance impresses me. The striking distention of her brood-pouch indicates that the contained young are about to break their maternal bonds. Also, the contortions she is undergoing strike me as being most unusual in a beast whose common attitude is one of rigidity or watchful immobility. Each bending and twisting is accompanied by the spasmodic opening of the four flaps adjoining the large cruciform slit-opening on the front of the brood-pouch. At the moment I do not connect this comical behavior with travail, and I laugh outright—but not long . . . a little antennaed head appears at the crisscross opening. Whether such inordinate writhings contribute to the easier egress of her young or are merely exertions to rid herself of incommodious baggage cannot be determined; at any rate, another moment sees the young skeleton-shrimp pull itself clear. And like a measuring-worm, bringing up its rearmost end and extending forward as it progresses, it clambers down the mother to hook its lower leg around one of hers, where it immediately assumes the mantid-like pose peculiar to *Caprellidæ*.

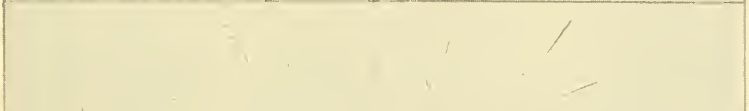
A minute or two elapses and another skeleton-shrimp climbs out into the world, and then another, and another, until I count an even dozen. Each in the manner of the first secures a hold on some part of the mother's frame and rears itself with all the perfection of an adult—just as if it had been doing this sort of thing times without number, for a succession of numberless years.

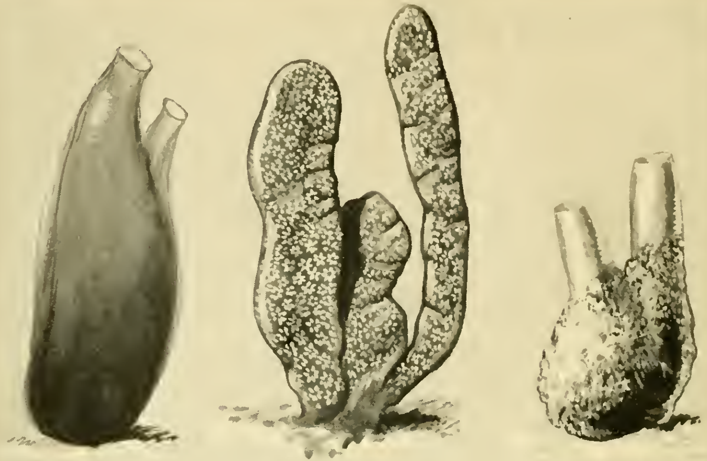
If any more youngsters escape from the brood-pouch, the fact is lost to me; for at this conjuncture I am compelled to take notice of the males; a fight is in progress between the pair.

Like two boxers, they face each other, their murderous-looking claws upheld in readiness to strike at the first auspicious chance. For a moment they remain motionless in an absurd attitude, in spite of its sinister significance. Then one with a seeming nonchalance brings over an antenna against the other's body; whereupon the latter with lightning swiftness shoots out his sickle-like claw, hooking his opponent around the head. Now follows some action. The other wrenches free his head unhurt, and bending forward seizes the offending arm of his foe with both claws. Although one of the antagonists is slightly smaller than the other, it is obvious that the two are evenly matched in strength. In fact, so evenly matched are they that it is hard for me to take sides . . . Am I forgetting myself? Yes, I am become a pleased and basely interested spectator of a bloodless brawl between two diminutive brutes . . .

The truth is, neither of the battlers, in spite of


POLINIA SP.
PLANOCERA SP.
STYLOCHOPSIS SP.
LEPTOPLANA SP.
PROSTHIOSTOMUM (?) SP.
FLATWORMS


POLYCIRRUS EXIMIUS
PECTINARIA BELGICA
POLYNOË SQUAMATA
SEGMENTED WORMS
WILLIAM CROWDER

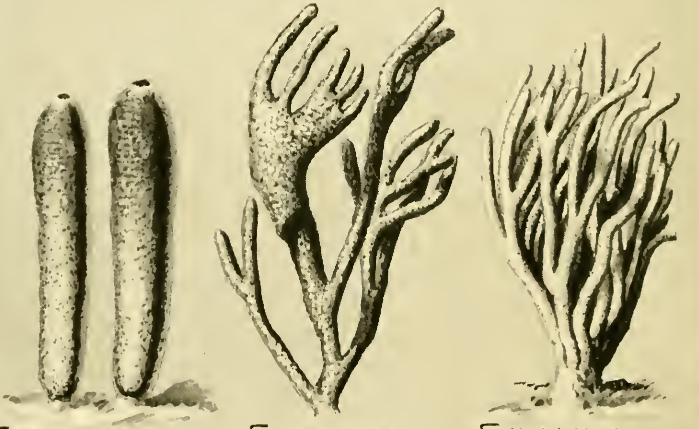


CIONA INTESTINALIS

AMAROUCIUM STELLATUM

MOLGULA MANHATTENSIS

TUNICATES



GRANTIA CILIATA

CHALINA OCULATA

CHALINA ARBUSCULA

SPONGES

WILLIAM CROWDER

the apparently dangerous weapons with which the fight is waged, is in the remotest likelihood of losing his life or limb. Their armored bodies and appendages are absolutely protected against creatures no more formidable than one of their own kind. It would seem, therefore, that all this energy is expended to no purpose. Yet who knows? Who can say what motives prompt the actions of such minuscules? That some motive moves them to manifest their belligerent regard for each other, there is no doubt. It does not follow that because they are microscopic their behavior is more purposeless or automatic than that of their larger relations, the lobster and the crab.

In any event, either is likely to conquer even if he cannot kill; he can win on points, so to speak. And I find myself deciding mentally to cheer on the shorter of the twain. But to my surprise each releases his grip and spends the ensuing five minutes apparently blissfully ignorant of the other, at the end of which the opponent of my favorite decamps, measuring-worm fashion, in the direction of the female. His purtenance appears not so praiseworthy as I had fancied; and, if I retain any respect for him, this display of cowardice loses it entirely . . . until I see him turn and make his way back toward his late antagonist. That individual is now rearing his head and claws aloft in the usual frozen attitude, menacing, frightful; but his back is turned to the other and is an excellent target for a tricky attack. That treachery is a part of the approaching skeleton-shrimp's plan, would seem from appearances quite probable as the plot begins to thicken.

This is becoming interesting. Ever nearer the crawler comes. By insinuative, progressive movements interrupted with an occasional statuesque halt, he advances to a point just within reach of the other and slowly starts to rear. Does the stationary animal see his foe? Instinctively I groan to apprise him of impending danger . . . He is nearly upright and apparently still unobserved.

"*Look out, little one! . . .*"

But my warning cry is wasted . . . There is no assault. There is no advantage taken by treachery. There is in fact no movement more hostile than a slight jostling as the larger *Caprella* reaches its full height to strike the same pose that is assumed by the other—that is to say, the pose that is normally assumed when waiting to seize upon floating food-particles or swimming prey. So close do they now stand that their bodies actually touch; yet not the slightest animosity is shown. Opportunity for no slight advantage is offered to the one who first strikes, but neither makes a gesture, let alone an attempt to attack.

What is the reason for this change in temper? . . . Well, among The Thousand and One Nights I have spent idling at the eyepiece of the microscope, many riddles such as this have presented themselves to view. They are not the least among the fascinations that the instrument reveals. But their solving requires lucubration and labor. And as this is but another of those Arabian Nights' Entertainments in that world of miniature marvels—purely a night of play—I refuse for the present to toil. But I catalogue for future consideration the foregoing question, which I know too well will forever remain unanswered.

CHAPTER FIVE

Jewels of Venus

I

IT was a perfect morning in May. My Faithful Assistant and I, for the past two hours since sunrise, had been combing a neighboring beach for such chance zoölogical treasures as were exposed by an unusually low ebbing of a spring tide. Steadily the sun climbed in a cloudless sky of beguiling blue, tempering gradually with a tropic warmth the chilled sands, the rocks, and the shell-strewn reaches that line that lovely strand. Not the slightest wind disturbed the transparent water through which could be seen the bottom and its gardens of greenery spangled with more than a million living stars; no mist marred the romantic beckoning beauty which distance lends to the verdant slopes of the opposite harbor shore. The surrounding scene was vibrant: the blue above—bewitching, bright-cobalt blue—was scarcely more intense in tone than were the colors of the cliffs and of the glittering sand around and about. Here high lights of brilliant orange flecked shadows of violet and mauve, glaring forth in the ever-increasing sunlight garishly, like those of tinsel or gauds. Below, as if it were one great solid expanse of emerald, lay the silent sea.

Already our collecting-buckets were laden to overflowing. It was with a measure of relief, then, after constant stoopings to turn up some animal hiding under a stone, and after frequent bendings over likely flotsam imbedded in the silt, that we paused beside a shallow tide pool to sort our material—to separate into smaller containers those of the more delicate creatures whose company with the clumsy and heavier specimens, such as crabs or encrusted rocks, would result in harm.

Our work proceeded apace with the sun, for there was still much collecting to be done before the day was many hours older when the tide was due to return, thus making further hunting impossible. But we never returned to the water's edge to complete our intended task . . .

It was my Faithful Assistant who first detected the teeming life in the tide pool near which we were engaged. It was literally alive with creatures large and small—fishes and prawns and ghost-shrimps and many other active swimmers which had been left entrapped by the refluent sea. And there were others here besides; sponges and polyps were attached to shell fragments, and various mollusks and worms could be seen on the substratum or ambling around. In fact not one of the eight great divisions of animals inhabiting the ocean was without one or several representatives in this natural aquarium set off from the sea. Nor was the plant life less conspicuous. It, too, was as varied and abundant. The blues, the greens, the browns, and the reds among the sundry classes of seaweeds all contributed to make up what was truly a marine paradise.

In outline, the pool was irregularly longer, somewhat, than it was wide, while its area was ten yards square or less; its deepest part did not exceed three feet. Soft cerulian shadows of seaweeds lay across the floor like blots of blue ink; every detail of the plant and animal inhabitants standing out in the crystal clearness of the water almost as if seen through the thinnest air. The dank dripping stones that lined its verge were slippery with growths of vegetation which in the morning sunlight glistened like streaming particles of mica.

Color was here, of course. For what tide pool containing so multitudinous a diversity is without its gamuts of chromes and lakes and its metallic lusters? . . . Yet, had color been wanting, there still would have remained to ravish the eye the prospect of line and form. Indeed, the loveliness that lay even in the indefinable, undulating outlines of *Pleurobrachia*, the comb-jelly, passing by, was of an order by itself and needed no enhancing hue; and there was *Fulgur*, the dog whelk, whose classic spiral shell was comparable in grace and nobility only to a Grecian urn; then in the larger lace-like compound ascidians was a stenciling and structure which could be classed alone with the exquisite wonder-carving creations of Burmese ivory workers; as for the coralline fretwork, such as was seen decorating the dome of a sand snail, none but the delicate and airy traceries of the Taj Mahal could approach it in beauty and purity of design.

But of the hundred high lights that could be pointed out in this imperishable scene at our feet, there was one which will long remain the most vivid in my mind's eye; it was the one which detained us from further wandering along the shore —Aphrodite, a sea-mouse.

It lay motionless near the very edge of the pool, resting on the bottom at a depth of about two feet, a blazing glory of celestial light. Here was a find indeed. Its scarcity in this locality I had more than once deplored in my endeavor to capture its colors on my canvases of sea life. In nearly a decade of constant searching hereabouts, I have come across just two specimens.

To capture it was merely a matter of stepping into the tide pool; but before doing so I resolved first to feast my eyes on this most gorgeous and gigantic of the ocean's living gems while it rested undisturbed within its natural setting.

Now I suppose it would give an added air of characterization if I could relate here how I did the conventional thing that all naturalists are supposed to do on an occasion like this—how, in my desire to study the sea-mouse more closely, I threw myself prone upon the wet and weedy edge, how, in utter disregard of comfort and for the appearance of my clothing, I maintained for minutes without end an immobile ecstatic posture lying in the mud. But I did nothing of the sort. I did the modern thing instead. I selected a spot within a few feet of the soggy edge, where it was comparatively dry; and after seating myself thereon, in the easy manner of one about to enjoy an outdoor performance, I proceeded to use my tele-magnifiers, or short-range field-glasses—that most invaluable aid to the naturalist who wishes to observe at close hand such small and wary creatures as are certain insects and crustaceans, or to study fishes and other timid folk in the immediate distance whose nearer approach is impossible.

Thus seen, Aphrodite loomed as large as if it were lying on my lap. Its flat body clinging close to the bottom was about six inches long, was broadest in the middle and tapered to a point at both ends—a contour not without grace, and extremely simple. Its back was thickly covered with brilliantly iridescent bristles forming a fur-like coat. Those growing around the margin were longer, some being fully an inch and bearing sharp points and barbs near the ends. These, like the quills of a porcupine, curved over the creature's back.

In exalting the beauty of a single sea creature, one must speak with caution, for so many are deserving of high praise. Yet I doubt whether the distinction will be challenged when I say that Aphrodite is for its size the most lustrous and colorful of all. It is true that others may exhibit an array of tints as pleasing and in every way as varied; it is true that the tender tones reflected by the shell of *Nautilus* are more exquisitely appealing; it is true that soft hues trembling over the surface of a comb-jelly are more subtly charming; but it is also true that they lack that indescribable richness, that pure chromatic quality which alone is Aphrodite's. Nor is it too much to say that nowhere else in the world is concentrated so much splendor, so much prismatic brilliance in so small a compass. Such rills of colored fire—such flames of bronze and blue and vermilion—are not to be conceived as existing elsewhere this side of the portals to the seventh circle of Dante's Hell.

And Aphrodite is a worm . . .

II

If I went at large into the subject of this most interesting tide pool, I should fill the remainder of the present book. I will, therefore, advert only to one or two more of its striking features.

To those familiar with the wealth of diversity that prevails in the sea, it is no secret that this region is nevertheless without a single plant that blooms. I here refer, of course, to that vegetation strictly marine, and not to those higher forms of the land which have become adapted to their newer habitat along the shore. To others this circumstance might appear puzzling were it not explained by the fact that seaweeds are without exception algal growths and therefore need no blossoms for their propagation. Nevertheless, it would appear that Nature has not neglected to endow the salt-water world with a floral beauty of sorts. Indeed, no greater grace is given to any than that which is found in certain flower-like animals of the sea; for theirs is that rarest of possessions: the perfection of symmetrical proportion combined with simplicity of form. In addition, they are oftentimes still more enhanced by the coloration of their parts or appendages—details always adorning, but making them doubly attractive when invested with even so common a hue as is their natural shade, sometimes of saffron, of brown, of pink, of blue. In truth, there are some among the hydroids, and the sea anemones, and even the worms, which compare favorably with the loveliest flowers of the land.

Such a one was *Serpula*, whose pulchritudinous petals I saw protruding from the opening of its tubular home. This calcareous covering it had built on a submerged stone at the very verge of the tide pool. In this accessible spot it was easy for me to watch its quarter-of-an-inch expansion of corolla under the hand-lens without disturbing the water.

But no sooner did my hand hover over the little "flower" than it vanished with surprising suddenness. As the nature and characteristics of this creature were well-known to me, I was aware that it would soon make its reappearance; meanwhile my wait was employed in studying its tube. This edifice, although not remarkable for beauty, was a masterpiece of architectural economy. Composed largely of lime, which the inmate excreted from the soluble materials it obtains from the sea, it wound irregularly over the unequal surface of its attachment for the length of two inches, whereupon it turned abruptly upward away from the stone for the remaining half-inch of its length. The one end of this tortuous chamber was closed and extremely small, showing where the young builder first began its construction. From this point onward the tube gradually increased in diameter until it attained to the thickness of a goose-quill at its free and open end. Certain sections also bore evidence from their color and texture that they were formed at different intervals of time; and from these appearances I was enabled to trace the facts of its age and the probable periods that the growing dweller within required additional space. Thus, I should say that its building was started but recently—not more than a few months prior to my May morning episode.

Lest this should seem to be draping a rather large or bold opinion over the peg of a very insignificant fact, I would point out that the paucity of information regarding this strange world obliges one to consider no fact as small; the least outwardly significant details are not seldom the most potential of certain knowledge. In further confirmation of my assumption—if such confirmation be needed—I might add to the chain of evidence just such a one of these insignificant details: the stone on which the tube was constructed. That stone, were there no telltale signs on the tube, would itself have told a story. From it alone could have been deduced the age of the hidden inhabitant. Certainly no living creature likely to attach itself on this half-imbedded base could have survived exposure throughout the winter months. Therefore, whatever the form of life may be that sought this stony sanctuary, it must, perforce, have found it after these frozen reaches were tempered by the vernal sun. Had this attachment been a shell or other scurfy fragment, the inference might have been otherwise; but the violence of wind and waves would have been insufficient to cast up a stone like this.

The door to this dwelling was closed by a plug, or operculum, which was part of the flower-like structure, a region really forming the gills. The reappearance of the creature's coronal branchiæ was signalized by the cautious extrusion of this operculum; and then it could be seen that this curious organ was placed at the end of a pedicel, or stem; it was fashioned somewhat like a funnel, the outside being longitudinally striated and the rim, or edge, fringed with sharp violet-colored points; from the middle another shorter funnel arose which also was bordered with points, but these were brilliant blue and were spread in such manner that it was less like a funnel than a pretty star.

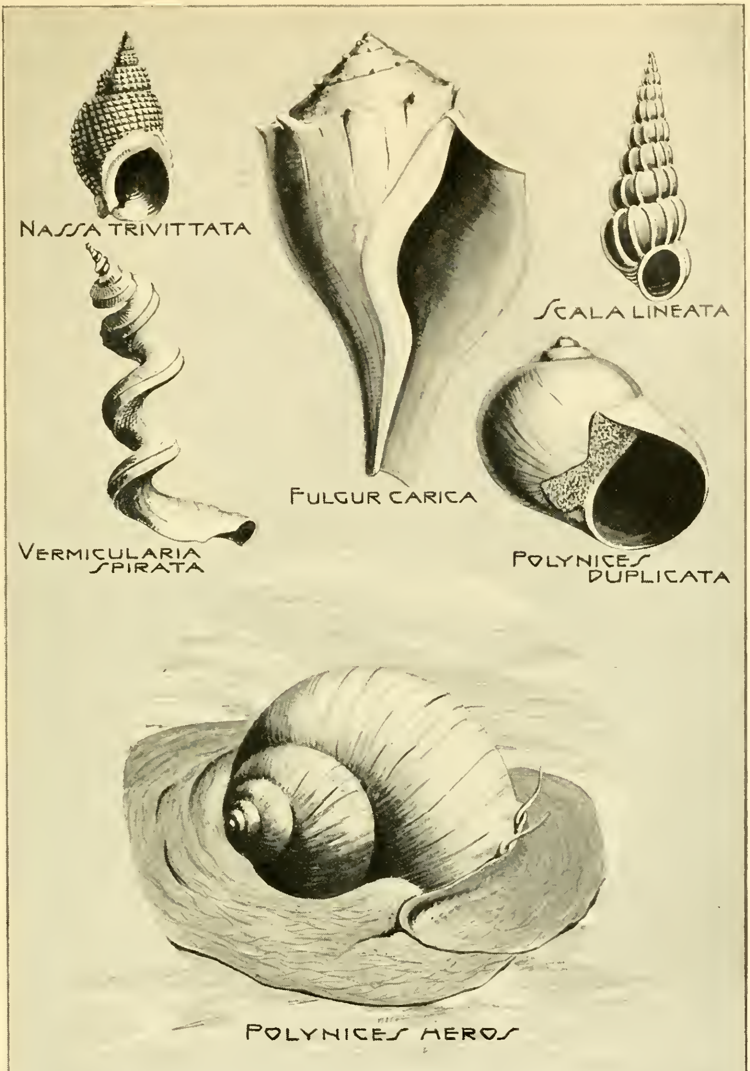
Almost immediately following the extrusion of this striking bit of stellate beauty came the breath-taking sight of the even more brilliant, but purplish-blue, branchiæ. Like the corolla of some ghostly flower, fast-unfolding, the diaphanous petal-like components expanded, revealing themselves as thirty-two transparent combs, each comb, more accurately described, being a long slender process covered on its inner surface with short spreading filaments which gave it more the appearance of a colorful, exquisite, phantom-feather.

Such was the singular beauty of *Serpula dianthus*—distant kin of *Aphrodite aculeata*, the sea-mouse. Need I add that this vision of loveliness was also a worm?

It soon became apparent, however, that the brilliantly colored breathing appendages have a dual function; they serve also as a snare. At intervals the worm would withdraw its gills into the tube with a suddenness similar to that displayed when I first approached it with my lens. That these sudden disappearances were due to other causes than from a sense of approaching danger, I determined by removing my hand from its neighborhood: the behavior was the same. I may say, in parenthesis, that the sense of sight in *Serpula*, as in all the higher, or segmented, worms that possess it, is developed only to the point wherein light is distinguished from darkness, or, at best, to such degree that only the crudest image of near objects can be formed.

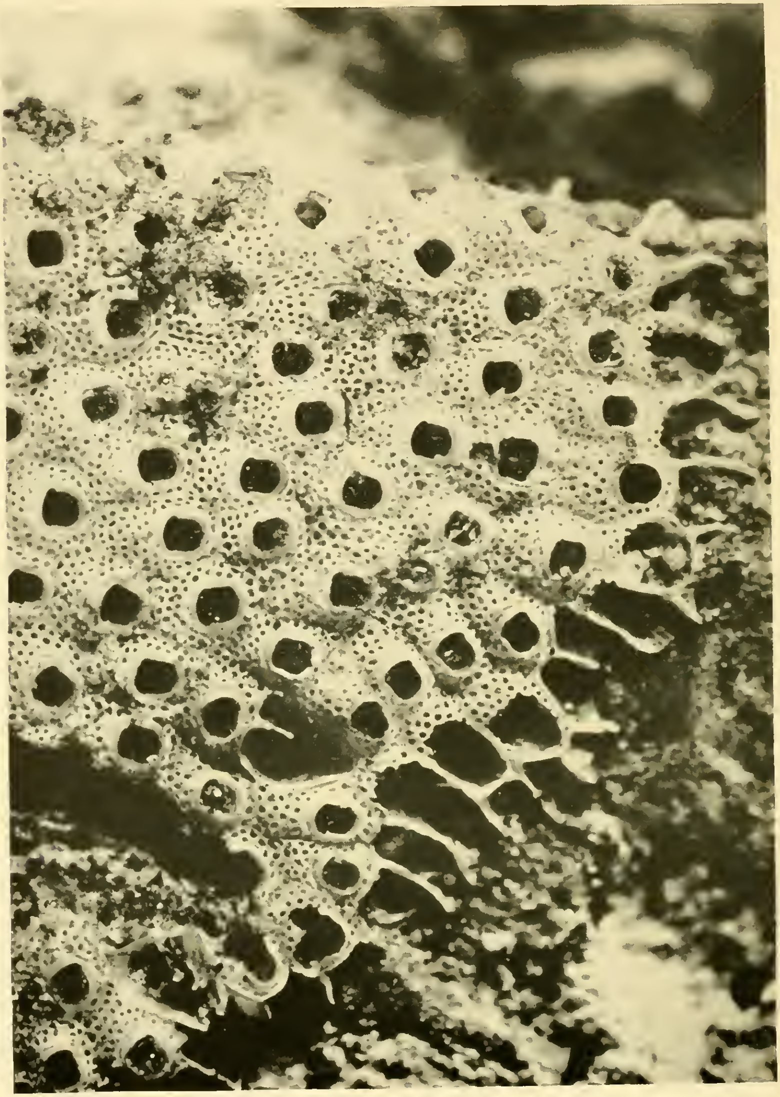
But a stronger glass and a more careful scrutiny made matters plain. It was patent that this tube-dweller, like the microscopic members of its class, derived its food from the floating particles drawn into the vortex of its branchial current. But compared with the whirlpools of minuter forms, that of *Serpula* was a miniature maelstrom. Consequently, a goodly-sized creature was occasionally caught among the streaming particles; when this occurred, the entangling petals closed around it like a trap, and the victim was instantly hauled into the tube to be engulfed.

Yet the frightful fact that this flower-like appendage functions as a deadly device, and the equally flagrant fact that its possessor is a worm, need not detract from one's appreciation of its inherent beauty.


NASSA TRIVITTATA
FULGUR CARICA
SCALA LINEATA
VERMICULARIA SPIRATA
POLYNICES DUPLICATA
POLYNICES HEROS

UNIVALVE MOLLUSKS

WILLIAM CROWDER



SKELETON OF A CORALLINE, ATTACHED TO AN OYSTER SHELL
Enlarged twenty-five times

There is, perhaps, no word in the languages of cultured nations so connotative of unpleasant concepts as the name by which the two foregoing described animals are commonly known; that is to say, the name "Worm." This word has ever been held and applied as a contemptuous synonym for what is lowest, vilest, and meanest in the opinion of mankind. I rise, not in defence of the worms, for however humble they may appear they require no advocate for their defense; I rise in protest as a human being against that custom born of ignorance whereby we succeed in slandering our intelligence rather than the reputation of the worms.

Owing to man's experience with the parasitic members of the group, and to the generally mistaken opinion that many obnoxious larval forms of insects are worms, he has looked upon the free-living forms as also unworthy of respect. This statement, of course, is only approximately true: the naturalist knows them better. He knows that there are few groups that afford more interesting study; he knows that in variety of species and diversity of form they exceed by far any other division in the animal kingdom, and that their habits and behavior are as varied and as diverse as their kinds; he knows that some of them have an intelligence surpassing that of many creatures more highly organized than they; he knows that nearly all of them have some details or feature pleasing to observe, and that not a few are among the most beautiful objects in the world.

There is a great and marvel-fraught field here awaiting the effort of the sympathetic historian. Some day, doubtless, some Homer will give us a real and revealing epic which will awaken the world to a proper appreciation of the wonders of their most amazing lives, to a friendly understanding of what it has so long regarded with loathing and with dread. And this cannot be forthcoming too soon. Too long has their praise remained unsung, their story untold; too long have these creatures, whose very comeliness, to say nothing of their ways, is worthy of the best that the genius of the poet and the painter and the essayist can produce, remained without a single gifted friend.

III

In removing the rock, that gave refuge to *Serpula*, from its place in the tide pool to one of the containers holding our collection, we disturbed a considerable population which had been hidden underneath. Small shrimp-like animals, transparent as glass, iridescent isopods and amphipods—crustaceans all—went skittering away from this common center like the fragments of a great jewel bursting in the sunlight, suddenly to disappear into the soft bottom or secrete themselves beneath some other rock or within the folds of an Ulva frond. Some there were, however, that did not partake in the general panic; these were a large gleaming specimen of the common sand-worm, *Nereis virens*, and several small related forms so inconspicuous that their presence would probably have been unnoticed had not some of them clung to the transported stone.

Now although Nereids are common, we saw at a glance that great gorgeous specimens such as this were not too common; whereupon, it was taken up by my Faithful Assistant to be transferred to its future home in the laboratory where it would serve at once as a living ornament, as an object of study and as a sort of pet. For strange and peculiar as it may seem in a worm, the highest of them (and *Nereis* stands near the very top of the class) are amenable to a certain amount of familiarity on the part of their human keepers; particularly are they tractable to the extent that they learn to respect and understand, if not to endure, the presence of the hand that feeds them.

The seizure of the worm was productive of much writhing and exertion in the vain effort to use its powerful horny jaws. These weapons, which are normally carried in the throat, resemble a pair of notched hooks with the points opposed to each other, and are brought into play by the extruding of the pharynx. But the adept hold which my Faithful Assistant retained just behind the worm's head, prevented effective use of these jaws—a hold retained partly from caution; more than once were we witness to their possibilities in previously observed members of the tribe, wherein they attacked their prey with such violence that the victims were bitten in two. And caution here was needful, for the body of our *Nereis*, rounded above and nearly flat below, was fully as thick as my thumb; in length it measured more than eighteen inches.

The sight of this creature is, no doubt, familiar to all who have had occasion to visit the seashore, and for such it needs no description; but for those of my inland readers whose conception of *Nereis* has been gained from words or pictures, further attempt at description here would not only be useless and unenlightening, it would also be a sinful waste of space. For the bald truth is, the likeness of such a creature cannot be reproduced. Of course, one can set down such coldly accurate details of its entire structure as the ten feelers and the four black eyes which adorn its head, the multitudinous blue-green segments of its body, each bearing a pair of pink leaf-like gills at the fore and shading into vermilion at the rear, and the sheaf of golden bristles under each flame-like gill . . . But that would not be *Nereis*—*Nereis* is an impalpable vision of dream-colors, an intoxicating shimmer of intangible shades, rather than a being of substance and form. And graphically to represent its appearance as such, with even a fraction of verisimilitude, is not within the province of the brush any more than it is within that of the pen. Ultra-chromatic spectacles like this are to be translated only by means of symbols. Yet I grope in vain for such symbolic aids as will adequately convey my own impressions of *Nereis's* charm: metaphors are meaningless, similes seem stupid, and superlatives are inane. How, indeed, express the nuances, mysterious and vague, fleeting along the length of such a living moonbeam as is this, when speech is silenced by the magic that lies in the mellow luster of a single segment!

Since its appearance defies description, I will attend without further delay to certain other features whose mention should not be omitted in even the most casual reference to this remarkable worm. These concern its general make-up and something about its habits—some of the facts I am only too well aware have often found their way into the writings of others. But not *too* often. For it would seem that, notwithstanding its wide distribution and common occurrence, its nature and capacity remain known to exceedingly few besides professed naturalists. I shall refer to them briefly.

Aside from the biological interest attached to *Nereis*, or the group it represents (the bristle-footed, segmented worms), because of its supposed position as a connecting-link with higher animals, it is intrinsically attractive by reason of its comparatively highly-organized structure. Above all other worms of other groups, it ranks far. It surpasses them not only in the development of its sense of sight and hearing, but also in the construction of its brain: distinct nodes, or ganglia, supply the nervous system, the largest ganglion being in the head.

This naturally presupposes a superior intelligence; and this is found to exist in fact. It is active in the pursuit of prey, and, as Augusta F. Arnold, the mother of modern amateur marine nature-study, has so succinctly stated, it is "fierce and voracious"—capacities which obviously cannot exist in any creature without some degree of cunning. It should be added, nevertheless, that its very voracity oftentimes leads to its own destruction. Twice have I encountered it, once dead and once dying, from having engulfed a creature larger than it could conveniently swallow. But what is more to the point, in the hunt for various worms and crustaceans upon which it largely lives, it must necessarily expose itself. This it does only at night, seeming aware of the dangers that threaten from even greater and greedier animals which are sure to attend an excursion during the day. Then it is, when darkness comes, that it leaves its burrow or other hiding-place and swims freely about, to become the frequent prey of the roving sea-robin or of lurking flat-fishes.

In keeping with the specialization exhibited in the rest of its structure, *Nereis* has a blood-vascular system. The blood is pumped through the body, not by a heart such as that organ is commonly conceived, but by a great blood-vessel lying along the back, which periodically contracts with peristaltic, or wave-like, movements along its entire length. Such oxygen as it derives must be absorbed through its gills; as a consequence these are continuously in motion, fanning the water, as it were, for fresh supplies.

The propensity of free-swimming polychætes for appearing in the open only after dark, is reflected in their habits of spawning. The eggs are freed in midsummer, always in the night, and usually immediately following sundown. From the manner in which many observers write, it would seem that this habit of spawning at night-time is a puzzling peculiarity. Just why this should seem so singular, I am at a loss to understand. The matter is really simple. Indeed, it would be odd were the worm to spawn at any other period. It obviously undertakes this important business with the same sort of caution that it uses to seek a meal.

In fact, even greater caution is necessary to this end. To insure the certainty of survival of the greatest number of young, it is necessary that the eggs be dispersed over the widest range possible; and to accomplish this the female must make more extended journeys than is her usual wont. What greater safety, then, can be offered for this than the cover of darkness?

During these nuptial nights, the males swarm the waters in myriads. But with the free-swimming polychæte worm it is wedlock without union. Both eggs and sperms are freed into the water to come into contact of their own accord. Now if there be anything mysterious about the whole affair, it is in the fact that this extraordinary swarming of the males occurs invariably during that phase of the moon when it is new, that is to say, during the only period of the month when the night is likely to be darkest.

From this mission of marriageless love, the males never return. The supreme purpose for which they lived now having been achieved, they resign themselves to death, making no effort to avoid discovery in the light of the morning's sun. Not so, however, is the case with the females; they are built of hardier, if not sterner stuff; before dawn arrives, each has found her way to the bottom or to some hiding-place between the tide levels on the shore. Still, although the lives of the males are normally terminated within twenty-four hours after the sexual swarming, few of them die a strictly natural death. Shoals of carnivorous fishes, hordes of swimming crustaceans, and flocks of gulls hasten to the easy banquet offered by the helpless millions. And in the wholesale glut which ensues, short shrift is made of the teeming mass of dying worms.

IV

"Come, look—see what I have found!" Again it was through the quick-sightedness of my Faithful Assistant that a discovery was made, to which I am bound also to give more than a passing notice. Particularly is this desirable as it will be complementary to the foregoing dissertation which dealt almost exclusively with the higher worms.

These words breaking in on my consciousness—I had been wholly lost in the contemplation of the colors of *Nereis*, who was now safely confined in a pail—brought me to her side where she was examining with a hand-lens some object on the rock which bore the serpulid's shell. "It moves! It is living!" With this exclamation, she handed the glass to me so that I could better scrutinize the cause of her excitement.

What I saw was a worm. But never by any twist of the imagination would it pass as such to those who hold the common conception of these creatures.

Its outline was roughly leaf-like, and its flattened form was exceedingly thin and without segments or other divisions to mark the specialized regions of its body. It was nearly an inch in length, while it was about half as broad as it was long. Although its coloration was not striking, it was not without interest, being suggestive of, rather than actually, a pale yellow tint which was veined with deeper tones. But the animal was semi-transparent, and this feature gave added emphasis to what was an apparent and singular fact: it was a worm that was little more than a living film.

With the sharp edge of my sheath-knife, I scraped it loose from the rock, to which it closely adhered, and placed it in a square vial of sea-water, where it could be examined to better advantage and on both sides. Literally to make head or tail of such a shapeless creature would not be easy from a superficial observation; but its numerous eyes, some of which were ranged in irregular rows along the margin, were most of them clustered toward one end which marked this region as the forebody. In all strictness it had no head. Its mouth was a conspicuous orifice underneath in the center of the body, where it served at once as the digestive entrance and the vent.

This describes the worm. It now remained to identify it. For when once the name of a strange creature is known, somehow a feeling of intimacy is established. To borrow for a moment some of the sesquipedalian words which garnish the literature of science, I found that this animal was classified as belonging to the phylum *Platyhelminthes*, class *Turbellaria*, order *Polycladida*, genus *Stylochopsis* and the species *littoralis;* which, when boiled down, means that it was planarian, the lowest of all living worms. But for the convenience of the reader as well as for the purpose of this record, it shall be referred to only as a flatworm—then, too, that is what it is. Moreover, *flatworm* is its common, besides being its appropriate, name.

A glance at its exterior alone would have discerned all that was necessary to know that a great gulf lay between the flatworm and the highly organized *Nereis;* but with more careful examination came a fuller realization of the vastness of that chasm. Inwardly as well as outwardly there was every evidence of a remoteness from one another exceeding by far that which exists between the monotremes and man.

To begin with, it had no respiratory organs, its breathing being carried on through its skin and perhaps the countless cilia which covered its body. Consequently it had no blood-vascular system, as by this simple process of obtaining its oxygen, none was needed. But little else would be required to indicate its low organization than to mention the fact that this flatworm can be cut into several pieces and each piece will regenerate a smaller, but perfect replica of the original. A modification of this power of regeneration sometimes gives rise to seemingly rare and peculiar forms not infrequently found free in Nature: if by accident they become merely mutilated, bizarre and freak shapes will result. And yet this abysmal creature is not without a comparatively high order of consciousness. It can see and feel and not improbably it can hear. Of its three sense-organs, the eyes, tentacles, and otocysts, the last-named are located within the anterior part of the body. These are minute crystals of lime contained in a sort of sac; it is to these that some investigators attribute the function of hearing. However, from what is known of their function in higher invertebrates, it is not unlikely that in the flatworm they subserve as geotropic organs as well; that is to say, it is through them that the animal maintains its equilibrium and orientation.

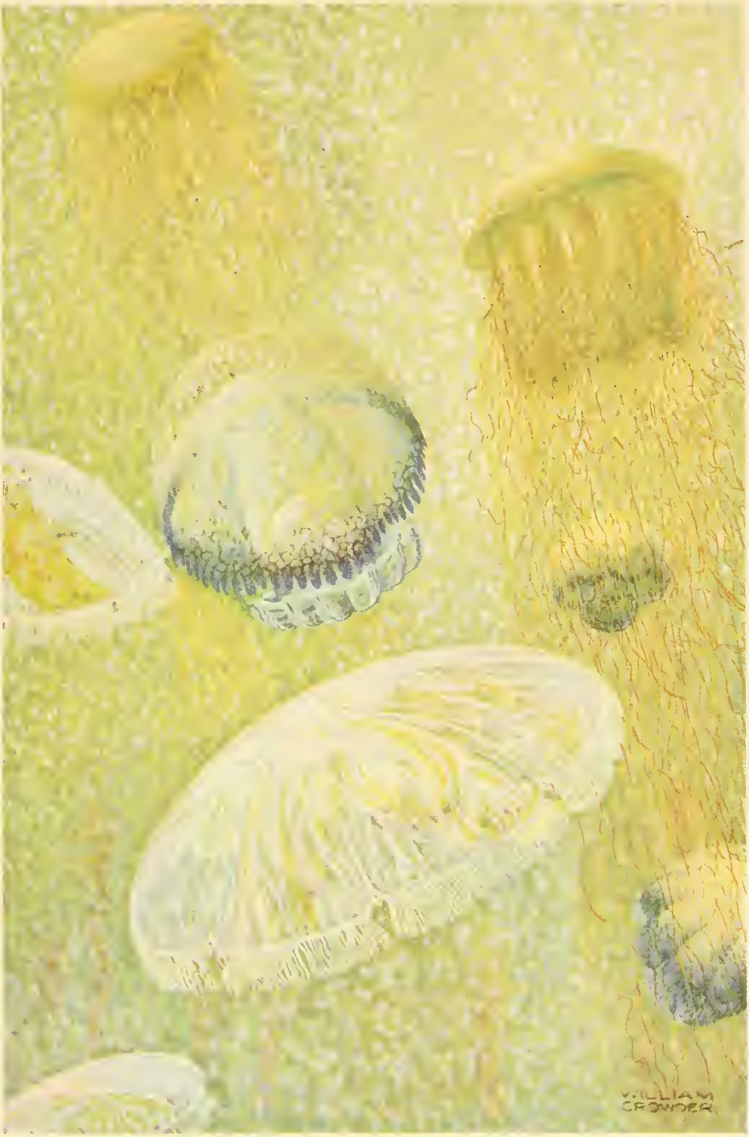
I have just referred to its order of consciousness. This requires qualification. It does not mean that consciousness in the flatworm involves intelligence such as we define this attribute in the case of higher animals including humans. Plainly, such psychic qualities are not manifest here. Yet regardless of whatever interpretation we make of this property of the mind, or consciousness, or whatever one chooses to call their equivalent, whether this property be termed instinct, reason, reflex, or free will, there can be no doubt that the flatworm is possessed of it to *some* degree. It is more than a mere automaton. Indeed, its predatory habits would suffice to indicate that; for oftentimes it swims around in search of food—a method of swimming, by the way, which is unique in this worm, for unlike the lateral movements of higher members of the group which swim in a serpentine fashion, its motions are up and down in the manner of the gliding course of the ray.

More often, however, it searches out its meals by crawling after them. Its locomotion is effected like that of a snail, that is, it is accomplished by successively raising, putting forward and affixing successively minute parts of its under surface; but the operation is attended by a feature more reminiscent of a caterpillar tractor than of a mollusk. The flatworm lays its own track. It exudes a slime over which its body travels without friction—moving like a flowing stream. Now, as to whether our species of polyclad, *S. littoralis*, may be regarded as an ancestral form requires more knowledge of its relationships than at present prevails, but it is at any rate very obviously a primitive type. And herein is found the first important structural feature in the evolutionary scale of animal life which has culminated in man. This is bilateral symmetry. It came as a consequence of the development of the flatworm's creeping habits. But another secondary trace of their result on the animal, and one perhaps equally important, was wherein its early efforts to creep led to the differentiation of the fore from the rear.

Although this flatworm is hermaphroditic, it is quite certain that it can not fertilize its own ova. For fertilization, it is necessary that sexual union take place between two separate individuals. The eggs are minute white spherules and are spawned throughout the summer months, but instead of being strewn broadcast in the water, as is the case with *Nereis*, they are attached in closely aggregated chain-like rows to stones, dead shells, and other submerged objects. And here again is found the beginning of an important factor which is retained even by human kind; however, it is a factor of function rather than of form. This factor is found in the female organs; for the flatworm invariably comes by its clutches of eggs according to the lunar cycle; that is to say, ovarian maturities occur a month apart.

LARGE JELLYFISHES

Cyanea: the sea-blubber (top-left and upper-right)
Stomolophus: a scyphomedusa (upper-middle and lower-right)
Aurelia: the moon-jelly (lower-middle)


WILLIAM CROWDER

LARGE JELLYFISHES

V

As it is the duty of the historian to interpret facts as well as to relate them, it may appear to some that I have not fulfilled this obligation in the case of the flatworm. But surely the discerning reader must have seen more in my meaning than the mere relation of dry details would seem on the surface to express; surely he must have divined from the foregoing how great is his debt to that lowly being; surely it must have occurred to him that it is owing to the early flatworm that he now holds his own commanding position among the creatures of the earth. In a word, is it necessary to interpret facts which so obviously speak for themselves?

Yet if this book has a purpose beyond the predominant one of establishing a fond acquaintance between the reader and these humble forms of life, it is that of forming also an intelligent acquaintance. And I should be loath to defeat these ends in a single instance—for who knows but that instance may be some potential naturalist who later may be moved to exert more than a passive interest in this remarkable group? Therefore, I shall conclude with another observation, in the light of which the preceding particulars will assume an unexpected significance as well as reveal their relation to the point of my theme.

We examined at some length the flatworm in the vial. Immediately upon its introduction into its glass prison, it glued itself to one of the plane sides and remained motionless; no attempts on our part by shaking or jarring the enclosed creature could disturb it from the place of its choice. It was evident that our captive did not choose even to crawl. But more than our temporary interest was now aroused; therefore, knowing that further observation would better be served by many than by a single specimen, we decided to hunt for more.

Time was passing faster than we knew. The silky rhythmic swish of harbor water creeping over the sands, ever nearer and higher with the incoming tide, was the first sound to break the vast prevailing silence. And it was this that awoke us to the realization of the fleeting time. In another hour the tide pool would be as one with the softly surging sea. The sun was now almost overhead; shortly would come the task of loading our little boat—then the long row home.

But within a short while we were fortunate enough to collect at least a dozen more of those much desired haunters of the dim and dark precincts of the pool. Here occurred a curious thing. No sooner was another flatworm placed in the vial with the first-found form than the latter began to show a marked activity. It released its hold from the glass and swam to the other, and after circling around the new-comer several times, came to rest at its side so close that their bodies touched.

Now this may mean much or it may mean nothing. Still, in view of subsequent observations with these creatures in the laboratory, a partial meaning can be found in their manifestation of sexual attraction; this behavior is in line with what not infrequently takes place preliminary to mating. However, what is more immediately to the point, it seems to suggest something also which is beyond physical considerations.

The flatworm, as I have already indicated, is a hermaphrodite. It is a noteworthy fact that most many-celled sedentary organisms have both male and female powers of reproduction. Plants in particular are well-known examples having this dual power; but its possession by animals, though not so notorious, is none the less manifest. For instance, such fixed forms as many sponges, as the coral, anemone, coralline, comb-jellyfish, oyster barnacle, and sea-squirt have contained in each individual the mechanism producing the spermatozoa and the mechanism producing the eggs. Among vertebrate animals hermaphroditism is rare; but it is known that the human embryo passes through a hermaphroditic condition. However, except in the case of some degenerate forms, parasitic worms, for example, sexual maturity of both organs in the same individual is not commonly coincident, and cross-fertilization is the usual method by which the species is perpetuated. Then, again, there are some species of flatworms which in early life are males only, but later they lose their masculine characters and become true females. And what is even more strange, still other species appear never to have had the functions of sex; in order to reproduce, they resort to dividing into pieces, each piece growing into a perfect adult. Obviously, this peculiar instance is not a primitive condition; it seems that somehow, in the long struggle for sexual differentiation, they lost their functions as well as the fight.

But our typical turbellarian, *S. littoralis*—if I may be allowed even loosely to apply the word *typical* to any specific representative of a group preëminently various in its forms and marked by seeming monstrosities, aberrations, and abnormalities—although engaged in the same struggle (for it is a true hermaphrodite) would appear to have won not sexual independence, but freedom of another kind.

If we admit the fact of evolution, we must grant also that it tends to operate at present from the same primary impulses that caused it to operate in the past. The machinery has since changed, but the motive power remains the same. In other words, to borrow a phrase from the philosophical biologist, natural selection is governed by immutable laws. Now, even were this not true, it yet remains that there prevail in Nature two laws which, in whatever light we may view these matters, are as fixed as they are fundamental: these laws have to do solely with the mechanism of digestion and the mechanism of sex, but they determine the existence of the species, whether it be that of the ameba or of man; and they may be exemplified in the one as the simple urge to eat and the urge to reproduce, in the other as the instinct to seek a mate and the will to hunt a meal. The obvious corollary of this, of course, is that these laws have prevailed from the time of the beginning of the first cell until the present day.

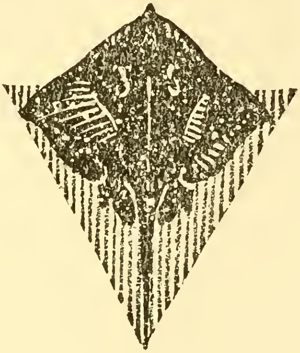
It is patent, however, that these laws are not of equal force as regards the individual organism. The law pertaining to reproduction is paramount —nothing in the lives of higher animals is more purposeful than the pursuit of love, nothing among lower creatures is fraught with greater urgency than the demands of this most potent of instincts or what passes for its pristine equivalent. In a word, the affairs of the stomach give precedence to the affairs of the heart.

From these considerations, it may at first sight appear as passing from the sublime to the ridiculous to speak of sex-appeal in a worm. Nevertheless, the fact cannot be disguised that it was at least something partaking of this element that led some simple-structured creature to grope its way out of the labyrinth in which so many forms were lost, and to arrive at the estate of man. And that this lowly creature was the early flatworm is not beyond belief. Thus conceived, it was a fixed form.

Like all sedentary marine animals, it solved the food problem by the simple method of living upon whatever morsels the currents brought within its circumscribed compass. With its wants thus supplied, it is unlikely that it was moved solely for the sake of sustaining itself to leave its attachment. But it would seem that the requirements of reproduction eventually were not so easily to be met. The same law of chance which furnished it with food was not so favorable in supplying the demands which arose for a mate. Opportunities for cross-fertilization apparently growing scarce, the flatworm at this conjuncture circumvented the threatened disaster to the further progress of its species by going into action. It created newer opportunities, in fact, by beginning to crawl, and perhaps by learning to swim. And with the escape from this sedentary bondage, came another sort of freedom: it is not improbable that, previous to this precarious stage in its history, the individual could reproduce by self-fertilization—a retrograde but a necessary resort in order to carry on until that more opportune day of emancipation. And in becoming sexually distinct in its functions, if not in its form, it became, so to speak, the first many-celled animal having similar sides, to pioneer in matters of sex, and, by the same token, the first to creep . . .

Here it may be objected that there are still lower animals to which one or the other of the foregoing attributes can be as easily applied—such, for example, as certain jellyfishes, which are single-sexed, and the anemones, which move about by crawling. But I would point out that the first-named are able only to swim; and swimming is the most primitive method of free locomotion, a fact which is found indicated in the embryological, if not the larval, development of all animals. As to the second-named form, its manner of crawling, the minutiæ of which cannot be gone into here, is totally different from that of the flatworm; moreover, its reproductive processes are not truly sexual, as this term is ordinarily understood. Again, it should be remembered that none of these creatures is a bilateral animal, a feature which preëminently distinguishes the flatworm.

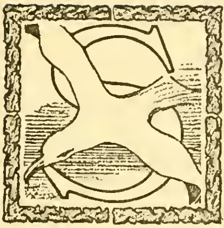
In truth, it is to this primordial precedent that man traces the reason for his own structure. The fundamentals of that reason, I have, I believe, now made clear. But how fraught with potentialities was this early essay to creep! How colossal was the consequence! And how tremendous is its import! That primal errand of love means something more than simply the beginning of bilateral symmetry: it was the first successful enterprise in Nature that ended with a human brain.



CHAPTER SIX

Revelations of the Night

I



STRAIGHT into the gleaming red path of a setting sun headed the *Hippocampus.* We had passed the bell-buoy at the entrance of Hempstead Harbor and were on our course out into Long Island Sound. In the fast gathering darkness, far across the water, could be seen the twinkling lights of several towns; and these glittered on the carmine crests, seeming like floating fireflies carried on a quivering sea of blood. The whole world was afire with color; even the white-painted *Hippocampus* was aglow with a reflected light of lovely rose.

The soft, sibilant wash at the bow was hardly less audible than the low hum of the motor as the boat pushed forward at slow speed toward the dying glory of the western skies. Never was a cruise more idyllic; never was a scene more tranquil, never was the water more serene. Nature, it would seem, was bent upon closing the day in perfect peace as well as splendor.

Then with a suddenness that sometimes marks the end of these Long Island midsummer days, darkness came. And the sea awoke with life. Draperies of light, which we knew to be jellyfishes, passed by in the depths, while the ripples from our wake ran with living fire. Here and there, around and about the boat, were the splashing struggles of fishes, fighting for some bit of surface-floating food . . . Gone from our minds was the glory of the summer night. Not even could the stars, pulsating in the vast and whispering void, or the moon now rising over the island hills, detain us longer. Their thrill gave way to that greater one which was ours in anticipation of the quest which was now about to be begun. The activity at the surface was a signal telling us that the awaited hour had arrived. The haunters of the depths had left their silent solitudes and many of the innumerable legion were by now well on their way toward the shore-waters to feed. I immediately set to work preparing the nets and trawl; and without further delay my Faithful Assistant took the wheel and opened wide the throttle, running the *Hippocampus* at full speed toward a great bight that lay to our left, less than a mile away.

The bight was well-known to us, and beloved by us both; many delightful days had we spent searching among its rock-strewn shallows and seining along its sandy shores; many, too, were the revealing and prolific hours we passed observing the ways of some strange or hitherto unnoted member of its varied population. Here, more so perhaps than in any other restricted place around these parts, were formed the greatest number of my own acquaintances with creatures not easily encountered outside the actual body of water composing the Sound. It was here, in fact, that I first met with that rarity in these ranges, the little sea-horse, *Hippocampus*, for whom our boat was named. It was an ideal collecting ground; and as such, its chief interest, of course, was a practical one. Yet such was its charm, derived in part from its sequestered situation and in part from the picturesque formation of its shore-line, that this alone would have been sufficient to lure us often to the spot.

Nor was it less attractive at night. Then particularly was its enchantment felt under the potency exerted by the light of a great blazing campfire. Then all the mystery of the purpose and meaning of its teeming life descended upon one from the outer darkness to dispel illusions regarding one's own importance in the cosmic realm of affairs . . . In those tremendous moments, the bight ceased to have being, and became a mood instead. One sensed it as a benign and pervading spirit, rather than as a physical fact.

But the full power of its spell was felt only in the light of a July moon—such as prevailed on the night whereof I write. From a beach of blazing light by day, it then became a stretch of ghostly gray, dim yet definable, fading at its farther ends into the mystic nothingness of the outer night.

This applies to the bight as a whole; but seemingly blue were the lunar lights and shadows near at hand; and here its real nocturnal beauty began. The all-pervading blue, it would appear, had entered the very sands. With every footstep, one left behind an imprint glowing with the soft sapphire light of phosphorescence. Nor was the water without its part in the ethereal picture: the gentle surf, breaking in waves of subdued fire, receded in rills, trembling with a million minute points of turquoise light.

On the night in question, however, my specific quest precluded more than a casual notice of the moonlit scene and its details of vapory blue. I had purposed chiefly to make some observations of the spider-crab in its natural habitat; but, as in every expedition of this kind, I was prepared as well to pick up anything new or strange which came my way, whether this were a specimen or a fact. To this end it had been desirable that I revisit the bight, and that I do so after dark.

Indeed, it should be added that for the primary object of my quest, a night-time visit was absolutely necessary. The spider-crab, in common with a great number of marine animals, is nocturnal in its habits, passing the daylight hours in comparative inactivity in the deeper water and moving toward the shore at night to feed.

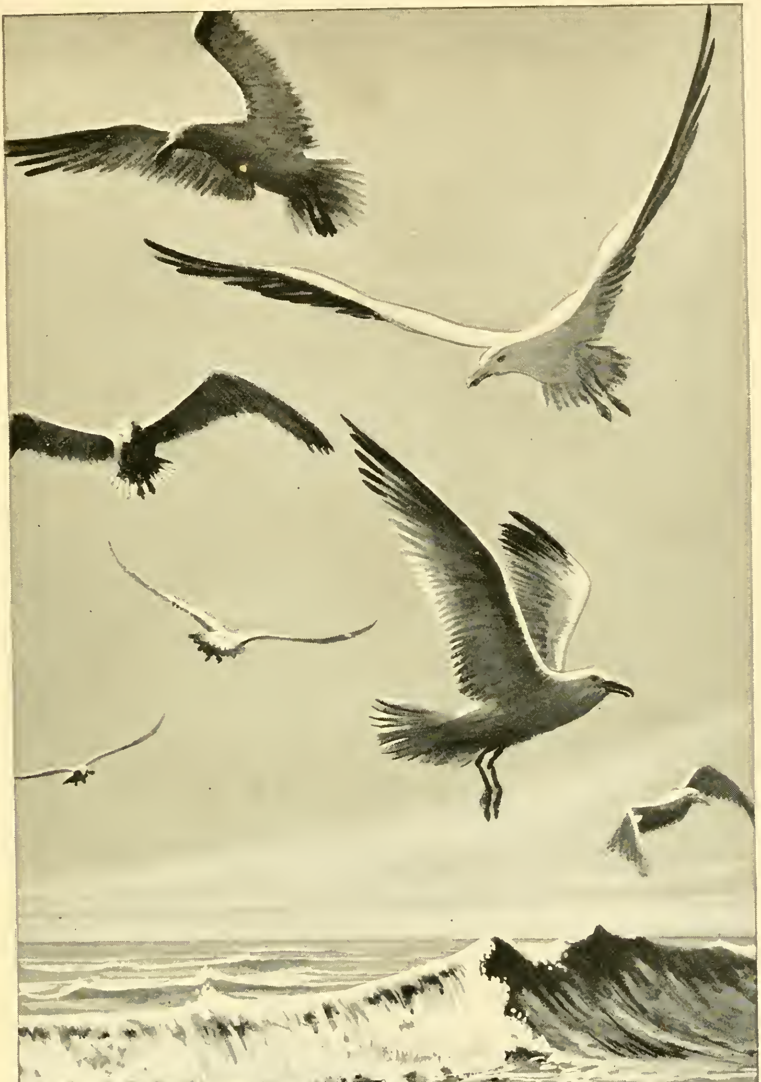
By the time the great shoreward migration, not only of the spider-crabs, but other crustaceans and fishes as well, had fairly begun, we had anchored the *Hippocampus* just outside the danger zone of a rocky reef within the bight and were loading the dinghy with our nets and pails. A short pull took us to a shallow spot, less than a yard deep, within a few feet of the water's edge; here under the strong beam of the motor-boat search-light, which with the battery we had removed to the dinghy, the bottom beneath us was illuminated with a circle of light which almost rivaled the brightness of day.

Such creatures as certain swimming-crabs and fishes which were usually so timid that they were practically unapproachable in daylight, seemed not to notice our presence, taking no alarm at the sudden illumination of their surroundings or the prolongation of the steady stream of light. In fact, many swimmers were attracted to the spot.

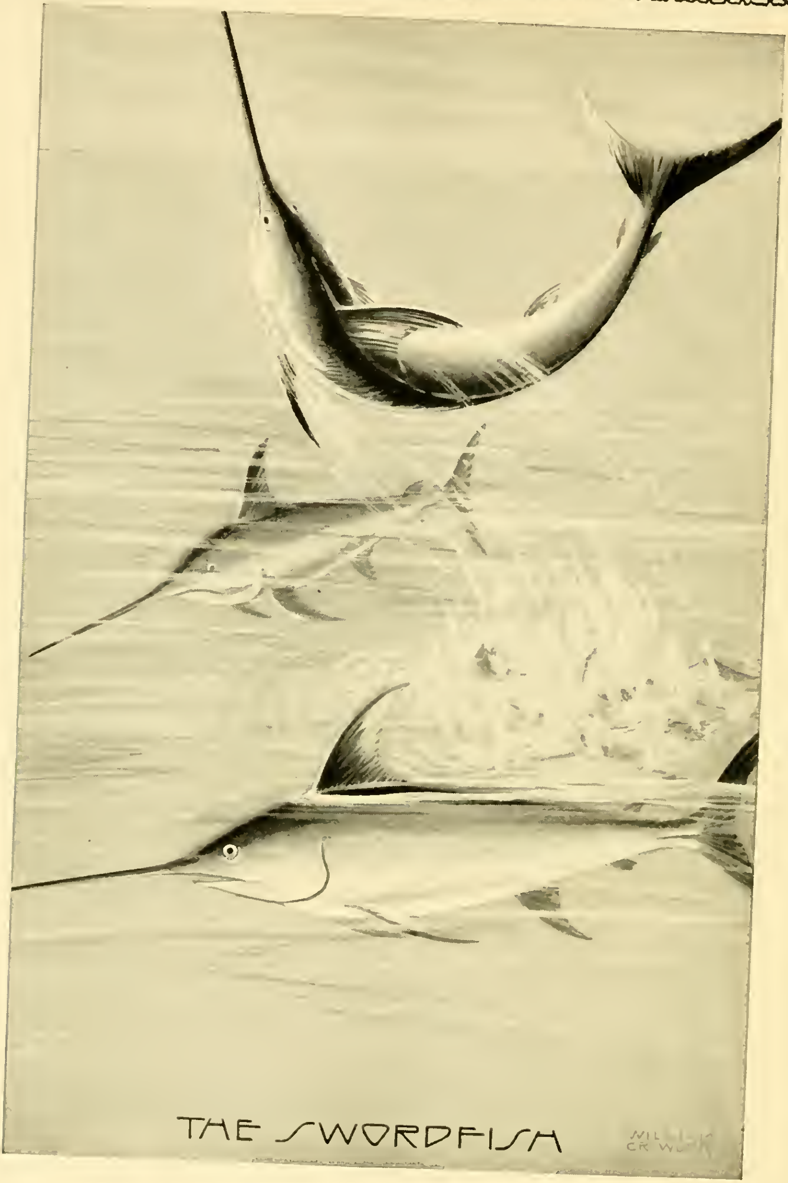
One of these was that molluscan terror of tiny fishes, *Loligo*, the common squid. As the spider-crabs, for some unaccountable reason, had not yet made their expected appearance in full force, I had ample time to watch the killing method of this weird brute. There is probably no creature among the larger animals of these shores that is possessed of a more ghoulish and god-forsaken countenance than this second-cousin of the romantic devil-fish, or octopus. And I here use my adjectives literally; for as I shall show in the present paper, as well as in a later chapter devoted to the life of this cephalopod, it is, besides being a killer, also an eater of corpses.

At first I was aware of the squid's presence only by the shadow it cast upon the floor. Then came the recognition of that fixed, stony stare. This latter detail could not have deceived me, even though the ghost-like form remained invisible; no other creature in the world has the hardness, the horror-inspiring look, that are in the eyes of the squid. Some silver-fishes swimming into the lighted area, in the close-bunched formation peculiar to their species, seemed to be unaware of the presence of their larger enemy, owing, no doubt, to the fact that that animal was in the meanwhile itself as invisible to them because of its well-known but peculiar color changes. The cause of these concealing changes lay in its power to control the chromatophores which covered its body: by the expansion or retraction of the freckle-like pigment spots, it was capable of altering its hue in parts or in whole, thus oftentimes simulating the general tone of its surroundings.

It was evident, however, that the squid saw the fishes, for it started to stalk them somewhat as a



GULLS
WILLIAM CROWDER



THE SWORDFISH

cat sneaks upon a bird. Built like an arrow—that is to say, with a straight and longish rounded body with ten sucker-arms in line with the head at one end, and a great arrowhead-shaped fin at the opposite end—it swam in either direction of its main axis with equal ease. It moved, so to speak, like a specter: without apparent motion of any of its appendages.

Finally the monstrous mollusk insinuated itself so near to the school of silver-fishes that I began to wonder at their obvious indifference to their danger. It appeared impossible that they could not now see their phantom foe. But at that very moment some quick-thinking individual, more alert than the others, sensed the situation and darted into the gloom; the remaining fishes, if not actually seeing the cause of this desertion, somehow became aware that something was wrong and all but one fled in fright. This one stayed because flight was no longer possible; the squid was within striking distance; and with a suddenness that I was unable to follow, it shot tail foremost into the departing school, and seizing one in its wicked-looking arms, brought the unlucky victim to the parrot-like beak at the base of these appendages and swam away.

II

The actual consumption of the captured fish we were not allowed to witness; the squid perhaps was fearful that some of its fellows, who were no doubt hovering near, would insist upon a portion of the meal.

We now should have been free to follow our original plan—for by this time the spider-crabs were coming in fast—but for a quite different though equally diverting episode which sought to detain us. In drifting over a small area of sand, we came upon one of those singular sights which emphasize the glaring contrasts so often found in the salt-water world. But in this instance the contrast lay not in a striking difference in form. We had just seen in one type of sea-dweller a display of ferocity; it was now our privilege to see in another the benign trait of friendliness.

Three full-grown rays, in nearly exactly the same manner as that of kittens, were amusing themselves at play.

To some it may seem strange that even a fish may be motivated in certain of its actions by impulses not unlike those manifested in the mental reactions of man. But that a creature such as the ray, a close relative of the shark, and therefore more primitive than any bony fish, should be credited with a conscious effort to indulge in the emotions of pleasure will probably appear downright preposterous. To some, in short, such lowly animals as these are little more than going mechanisms composed of flesh and blood, if not in part of bone. Indeed, I do not deny that this was once my own belief; but increased familiarity with marine animals has obliged me to modify completely certain details of this purely mechanistic view.

Nor do I think that the course of my own convictions differs greatly from that of other workers in this field. I believe that the history of many students of practical experience can be divided into three stages: the first, in which ignorance and enthusiasm causes the tyro either to read in the actions of animals evidences of his own familiar psychology; or, in his eagerness to account for a performance he does not understand, to interpret them as arising from traits and an intelligence entirely human-like: the second, in which an inevitable reaction occurs because of his more extensive contacts with fundamentals, wherein he looks upon mental initiative as non-existent; the animal being merely an automatic organism whose reflexes are conditioned solely by external factors—and here he leans farther backward in his reasoning, so to speak, than he was previously inclined toward the anthropomorphic view: the third, in which still further experience fails to confirm his convictions, and in which he eventually is obliged to reckon with the fact that animals of the same species, among other mental endowments, are possessed even with a temperament; differing among themselves in this as they differ physically—just as humans do. And he finally concludes that although the mind of man has superior qualities, that of the lower vertebrate is essentially the same; which is to say that he knows as little about the matter as he knew at the beginning, excepting, perhaps, that he realizes the paradox that his acquired ignorance is owing to a fuller knowledge.

Yet, even though experience were wanting, reflection alone should oblige us to believe that the "brute" is not so "dumb" as it may seem. I think we can agree, without violence to our egocentric notions, that there is much in common between the minds of all beasts possessing a backbone, and this, too, we can do without in any way ascribing to the lower animals such a high degree of psychical development as that which distinguishes us as humans.

And that rays, therefore, play solely and purposely for pure diversion, let us not doubt. The well-springs from which even a gnat derives its liking for light and warmth are the same as those which give rise to the love for the pleasures of sport in every normal human breast.

Nor is it improbable that the enjoyment of those whose actions I am describing was as keen as that of the kittens whose antics I have said were similar. The bodies of the rays, being broad and very flat, did not allow the lightning quickness of movement that is in the young cat, but the tactics employed were much the same. At first one would rest upon the bottom, its wide wings everywhere in contact, where it awaited in seeming apathy the stealthy approach of its two companions. Then, no sooner were these latter near than the resting ray, with that graceful gliding motion of its wings, which is characteristic only of this peculiar fish, curvetted upward and around, describing a short circle, at the end of which it came upon one of its playful tormentors and tried to bowl it over. This it essayed to do by wedging its snout between the other's wing and the sand. However, as this was apparently a game at which more than two could play, it was leaving the third member of the party out of the fun, whereupon that individual came to the side of the one now turned aggressor and assisted in trying to dislodge its former partner.

Their combined efforts might have succeeded, had not the resting one decided that enough was enough and suddenly swum to another spot nearby, settling beside a clump of mussels where it awaited the approach of the others with the same obvious indifference that marked the conduct of the first-mentioned fish.

And so the game continued, each ray taking a turn at the playful, yet seemingly serious, business of holding its post on the sand. There was an occasional variation, however, which consisted of a general nosing and jostling by all three at the same time. Doubtless, too, our own engrossment in this pleasing spectacle would have continued to hold us for many moments longer, in spite of the demands of that more serious business which awaited us, had not the rays themselves brought their pastime to an end.

Something had happened which caused a sudden change in their behavior. The former security which marked the conduct of their employments, now obviously existed no longer: their feelings, unmistakably manifest in their deportment, were those of fear. From the easy ponderosity that distinguished their movements while at play, the three rays were galvanized into greater action by fright, and sped swiftly out of view. What was this mysterious danger which their sight or scent or unknown sense had apprehended? I looked around, but saw nothing. Then swinging the search-light so as to sweep the water in all directions, I presently revealed what I can describe only as a fearsome vision. Within fifty feet of our little boat, motionless in the hazy distance of the water, was a gigantic specimen of the blue shark. Trailing from the region of its mouth was an ill-defined object, but I immediately surmised that it must have been some sort of fish which the great beast had recently caught and not yet consumed.

Notwithstanding my familiarity with shore sharks—creatures common to this neighborhood, small in size and generally inoffensive except for the havoc they wrought when entangled in my nets—the sudden sight of this rare visitor from the reaches of the broad Atlantic was not without a thrill. Indeed, had I not been nearly inured to unexpected encounters, this apparition probably would have been provocative of more than merely a thrill—doubtless it would have frozen my blood. Even so, frankness compels the full admission that previous training was at that instant forgotten; my usual matter-of-factness in meeting with this huge wanderer was woefully disturbed; in short, such was the suddenness of this revelation of the night that it came with a transient, but distinct, shock. And yet it was not the nature of this notorious beast that struck the passing note of terror in my heart: what startled was its seemingly enormous size. Actually a full seven feet long, it loomed up in the shallow depths as large or larger than our tiny craft. A blow from the tail of a creature of even lesser bulk would have been serious business, perhaps preventing our reaching the anchored *Hippocampus* without an arduous swim, to say nothing of the loss sustained.

Something of these apprehensions escaped my lips. But at that moment my Faithful Assistant burst into laughter. What was this—hysteria? If so, it was strangely inconsistent with the emotionless courage which I had formerly and frequently observed when sharing with her far greater and more seemingly imminent dangers than the one which now threatened. But my suspicion barely arose before she added in a tone unmistakably self-possessed, "Why, don't you see?—the thing is dead!"

It was true—the shark was dead. So dead was it, in fact, that decomposition had long since set in. On pulling up to where the floating bloater lay submerged, it became evident that it was its condition which had caused the presence of the object discernible at first sight near its mouth. Our approach, however, alarmed it, and it slunk away, disappearing in the dark waters. But it did not go fast enough to deceive us as to its identity. It was a squid.

We soon learned from the presence of still others which streaked across our groping beam of light, that a school of these animals was hovering near. The individual of our early encounter, and the one just engaged apparently in tearing away the lips of the drifting carcass, were doubtless members of this school. Nothing now could be plainer than the reason for the interruption in the playing of our rays: it was because of the close activities of these corpse-eating killers.

III

It was now high time that we began upon the business that brought us to the bight. But, in a way of speaking, although the scientific spirit was willing, the thrill-loving flesh was weak. It would seem that the side-plays in the moving drama of the water had conspired to keep us from focusing our attention on the main action of the piece. Therefore, the actual start of our watchful enterprise was not yet. Hardly had we turned toward our intended task when we became aware of a subdued slapping sound coming from out of the darkness, somewhere forward of our bow. With an ear grown acute to the various accents in the spoken language of the sea, I interpreted it at once as some creature struggling at the surface.

And now that the matter of the dead shark no longer concerned us, it came to me that I had heard this sound before. Softly and only at intervals it had fallen upon my ears unnoted at the time; yet somehow it had crept into my consciousness impinging itself vaguely, dimly upon my memory. Suddenly alive to the realization of its meaning, I looked about, straining to hear its repetition, the exactness of its whereabouts.

At the same instant the search-light was directed forward; a moment more and the brilliant beam picked up a small black object floating on the surface less than a hundred feet away. As we pulled toward this oddity it made an ineffectual attempt to rise from the water and revealed itself as a bird. Then it was that I distinguished the cause of the occasional subtle sounds which finally made themselves felt, as well as heard, in the absorbing silence of the night. It was not until we were well upon the bird that I was certain of its kind; although to me the sight of these sable cripples was not exactly new. It was a glaucus-gull; its identity was betrayed only by its beak; the remainder of its body was coated with pitch.

The fatigue of the bird was apparent. Despite its efforts to swim away when the dinghy neared it, we were easily able to overtake it. Nor could a more painful attempt at flying be imagined; its feeble flapping failing even to carry the creature forward; the pitch utterly preventing all possibility of rising. I reached for the dip-net, and scooping up the exhausted gull I deposited it on the bottom of the boat.

What a sight! The sticky oily mass with which it was covered had penetrated its feathers to the skin. It had retained the use of its left eye; the other was as thickly smeared as was the rest of the body even to the webbing of its feet.

I was for killing the gull at once to put it out of its misery, but was opposed by my Faithful Assistant who, it seemed, had already formed a plan of her own. She was for leaving me on the beach with a hand-net and flash-light together with other paraphernalia to follow the movements of the spider-crabs by wading, while she returned with the bird to the *Hippocampus* where, with some gasoline from the fuel-tank, the creature could be cleaned, perhaps thereby prolonging its life.

Reminding her that this would involve further care until the patient regained its strength, and would add to the litter as well as the labor now already great in connection with the hospital being made of our house and premises—which now contained such convalescents as six herring-gulls with broken wings or battered bodies; three crows, ditto; ten tortoises with limbs or shells crushed by automobiles; one blue-jay blinded by roup, but now on the way to recovery; one heron wounded by gun-shot; one starved porcupine and one sick racoon wished upon her willing nature by thoughtless but well-intentioned persons who had captured these creatures in other parts; one young alligator suffering from the same symptomatic causes and for the same reason; and all of whom would have likely perished but for her untiring attention to their wounds and her sympathetic understanding of the wants of such wild unfortunates—reminding her, then, of all of this, of the trouble her proposal entailed, I was given in return the unanswerable argument expressed in the simple statement, "Of course."

So without further debate, I placed the gull in the bow of the dinghy preparatory to pulling for the shore. Here in the glare of the search-light the bird stood, the most dejected object imaginable, but retaining enough interest in life to keep all our movements under the apprehensive scrutiny of its uncovered eye. My Faithful Assistant further evidencing her compassion, scooped up some mussels, and breaking one open threw the meat toward the famished bird. Weakened as it undoubtedly was, it showed extraordinary vigor in snatching the food which was offered, catching the morsels in mid-air as fast as they were tossed. Despite the handicaps under which it labored, it was unerring in its method, never once missing the flying fragments of mussel-meat.

But a more amazing evidence of this peculiar alertness was presently to be seen. Picking up a small piece of cork from the bottom of the boat, I sent this the bird's way. It was ignored completely. Somehow, probably through its sense of smell more than through its sense of sight, the gull was able to distinguish in the short space of time that the cork took to travel from my hand, that it was inedible. Repeated trials, alternating cork, wood, and even bread—which this breed seems not to eat—with mussel-meat and an occasional minnow—of which it is fond—failed to betray it into making a single mistake.

By the time we reached the shore, our helpless waif had regained sufficient strength to walk around the bottom of the dinghy. There we left it to its roamings while we removed some supplies to a point above the tide level. This done, my Faithful Assistant set to work at building a fire, whereupon I began to explore the beach for sizable pieces of driftwood, and to gather them in such quantity as to maintain a large and lasting light, a beacon for her return. Besides, its embers would later serve to boil our coffee and roast our midnight meal.

But firewood was uncommonly scarce, and my search took me farther away from our selected site than I had realized, when a hail from that direction caused me to drop my load and to hasten back as fast as my encumbering boots would permit over the soft and yielding sand.

That my Faithful Assistant had come by chance upon some rarity or had observed some creature whose employments demanded my immediate attention, I did not doubt. Often before, her call had brought me to witness some transient and eventful sight; so I had learned to respond quickly, lest an opportunity for taking in a most unusual detail, it may be, become forever lost. As I drew nearer, however, I saw in the bright moonlight that she was not in the water but was sitting in the dinghy which had been left resting on the sand by the receding tide. With head bowed she was looking intently at some object she was holding in her lap.

In this attitude she remained until the sound of my approach told her of my presence. She looked up, but said not a word. Nor was it necessary for her to speak. I saw in a glance what had occurred.

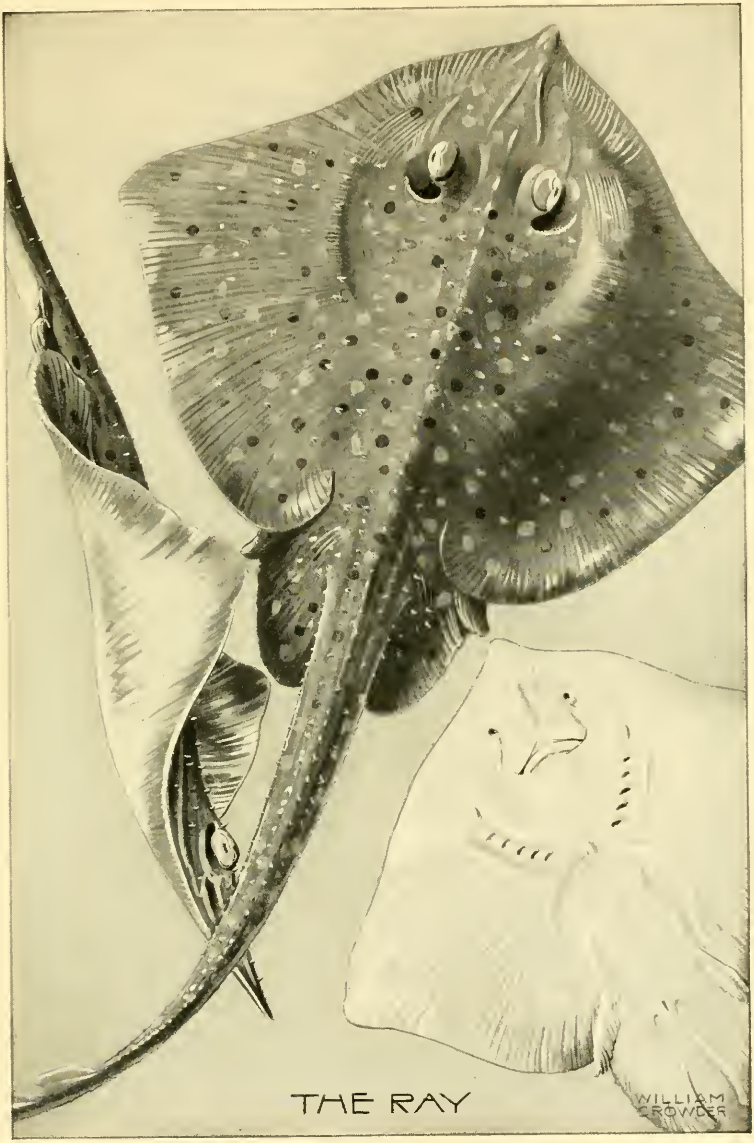
The object in her lap was the oil-soaked gull. And it was dead . . .

Truly dead. Its recovery after eating had been but temporary. The poisonous pitch in its plumage and its previous struggles had proved to be too much. The weary frame had given up the fight at last.

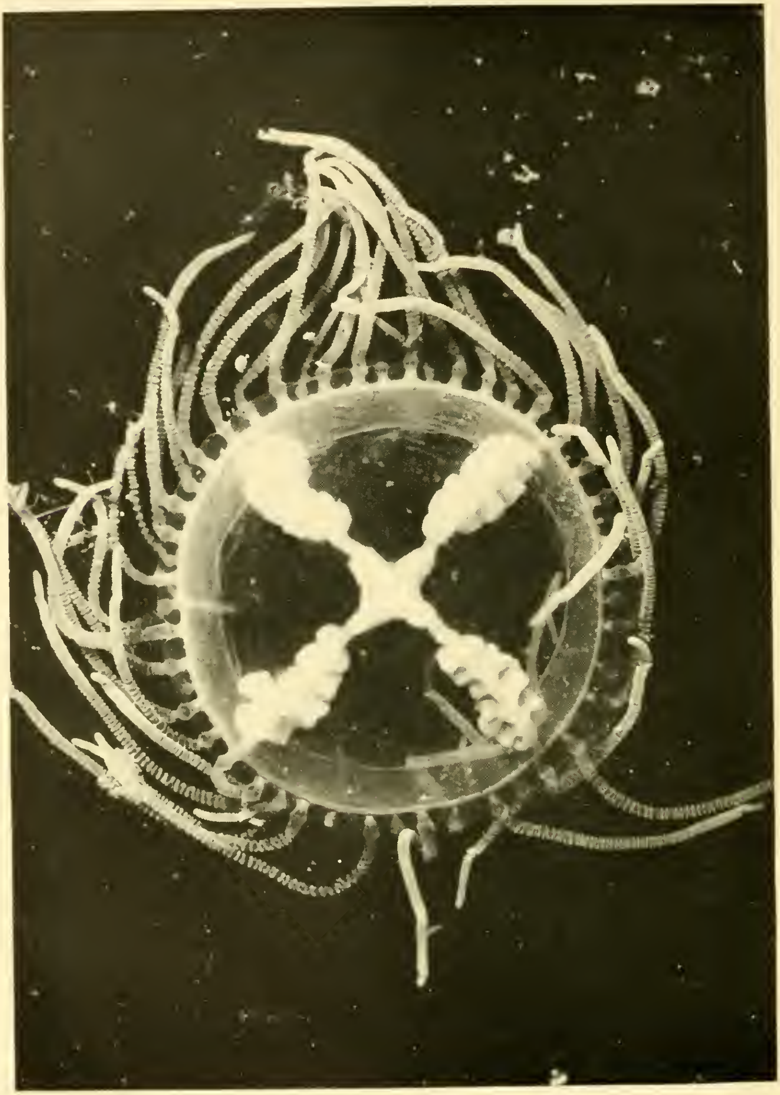
I regret, Reader, that this incident cannot be closed with the conventional "happy ending"; I fain would tell how care and kindness had finally restored the bird so that it eventually was able to rejoin its companions of the sea; but history, not romance, must be served.

Yet, having given without reserve the details of this unfortunate incident, candor also compels me to add some further pertinent facts.

As every one who has the least acquaintance


WILLIAM CROWDER

THE RAY



Gonionemus, A HYDROID JELLYFISH
Enlarged five and one-half times

with the bird-life of the Atlantic seaboard knows, literally tens of thousands of gulls and other feathered swimmers die annually as the result of the oil and tar discharged into the waters of rivers and harbors by industries and into the ocean by oil-burning steamers. In vast floating "lakes" of this refuse, flocks of birds unsuspectingly alight and become covered and weighted so heavily with pitch that they cannot rise from the water. Thus caught, they eventually succumb to fatigue or starvation, or both.

However, there is another aspect to this matter of polluting the sea. Aside from the commercial waste, carelessness, and inefficiency which it unquestionably indicates, a considerable economic loss is involved. The poisonous nature of the pitchy substance makes it deadly to plankton; it kills off minute floating plants and animals upon which many of our most valuable food-fishes indirectly depend. This applies with even greater force to shell-fish, for edible mollusks subsist directly and entirely upon minute floating food. Indeed, the damage is still more far-reaching: valuable migrant food-fishes visiting these shores, upon finding their fare depleted, turn to less contaminated coasts of other countries to seek sufficient for their needs.

It was into one such of these death-dealing, unsightly, drifting sinks that our now lifeless gull had found its way.

IV

Midnight was the exact time of low tide. By this hour I was finally and fully occupied with the creatures which I had originally set out to watch. I was alone in the dinghy. From where I sat looking down into the clear lighted depths at the spider-crabs crawling about on the bottom, the sounds of frying food being prepared by my Faithful Assistant on the beach could easily be heard—or to be more exact, they could have been heard, had I just then the ears to hear. The moon, now at its highest point and illuminating the landscape with a superb soft brilliance, was reflected in the water almost directly underneath; its image, broken by the undulations of the wavelets, appeared like running quicksilver. But little did I reck of such sights now: a more moving one was holding me.

A bed of mussels barely three feet below the surface was alive with crabs which I had had under surveillance for the past hour or more. Although their actions had not been devoid of interest, nothing really novel occurred. In conformity with the usual feeding habits of this species of spider-crab (*Libnia emarginata*), they had sought the mussels after sunset, where they plucked off hydroids and other zoöphytes attached to the shells of the mollusks. Occasionally this diet was varied by breaking open the mussels themselves; which they were easily enabled to do with their powerful claws.

Males and females in about equal numbers had been thus employed; the former were easily identified from the latter by their claws and larger size generally. All were sluggish in their movements, their actions at times being grotesquely deliberate. Their bodies, broad and round behind, tapering to a point in front, were covered with prickles and stubby hairs, to which often were adhering particles of seaweed or debris; in some instances barnacles and hydroids were seen attached. Withal, their frowsy bodies, comparatively small in proportion to their long slender legs, would alone suffice to have given them their common name, without the aid of their spider-like appendages. Some specimens must have been more than thirteen inches overall.

It was while noting such familiar, but ever absorbing, details of crustacean life that my eye was caught by a new-comer; a spider-crab of an entirely different kind strode gravely into the scene. My heart gave a perceptible jump; immediately I recognized it as a female *Hyas coarctatus*, and a representative of a genus famous for containing the most intelligent of all crabs, if not the very smartest of all invertebrates; it was a creature I had long been looking for, but had been unable to obtain easily, owing to its infrequent appearance in this precise locality of the sea.

In truth, my interest in *Hyas* had antedated even my first-hand acquaintance with the crab folk of the sea; long ago, upon reading of its remarkable traits, I had resolved that one day the study of certain of its singularities should be mine. Here was the chance. At last my laboratory was to contain a royal guest, the Queen of Crustacealand, a real aristocrat. And by this I mean a being of intellect; for I hold that no title of nobility exists but that proceeding from a superior mind. I made ready for her capture, then paused a while to watch.

The traits referred to in the foregoing were those concerned with the *Hyas's* method of concealment, the manner in which it made itself invisible or inconspicuous by fastening different materials to its shell; but, curiously, the spider-crab which I now saw had none of these signs of camouflage. Her back was as bare as the proverbial bone.

The reason for this, however, soon became apparent. She proceeded without a stop straight toward a clump of sea-lettuce containing several large fronds which in their upward buoyant reach cast long black shadows across the floor where they finally blended with the even intenser blackness of the mussel-bed beyond. And then occurred one of those brain-baffling crises when for the moment I was hard put to convince myself of the credibility of anything that passed before my sight . . .

The clump of seaweed began to move toward the oncoming spider-crab! . . . They met. Then two great claws reached out from the clump and a pair of long arms folded themselves around the unresisting female, gathering her close to the base of the lifting fronds.

At this conjuncture it came to me why the female was without the usual regalia of her kind. (The reader has no doubt guessed that the sea-lettuce masked a male.) In accordance with a custom prevailing among crabs generally, this creature could receive the attentions of a mate only during her time of molting. This is to say, she was in the so-called "soft-shelled" stage. Having just cast off her old shell, with its adhering decorations, she must await the hardening of her integument before donning another disguise. Moreover, it is conceivable that were she able to affix anything to her soft hooks, her wearing of such artificial raiment would somewhat hinder the nuptial embrace. In fact, for purely protective purposes, she now needed no such cover: the panoply of the male was ample to hide them both from view.

I awaited no longer. With a sweep of the dip-net, the pair were caught and lifted into the boat.

Thus, it seemed, my laboratory was destined to be graced by the presence not only of the Queen, but the King also would be there to shed some glory around the lot.

With such a prize in my possession, I was not slow in reaching the shore and acquainting my

Faithful Assistant with the fact. Proudly revealing the spider-crabs, I related in glowing terms the circumstance in which I came upon this rare and fortunate find. No detail was too trivial to omit relating in this signal event.

Now always in previous discoveries, she had made my enthusiasm her own. But this time I was heard with apparent apathy; my efforts to interest her meant nothing; and I wondered at the cause. But, no, a lurking twinkle in her eye undeceived me. Yet, without venturing a word in reply, she turned away and walked several dozen paces along the water's edge where she seemed to be looking for something on the sands. Obviously it was a mark, for here she paused, her white sports dress and canvas shoes showing up sharp and bright in the magnificent moonlight. She found it. Then, stepping into the water, she waded straight out to a point a few yards distant where the depth was about up to her knees.

With ever increasing wonder, I continued to watch. Nor was the motive of her capricious action any clearer when I saw her stoop and try to dislodge a heavy stone from where it was submerged. Finally she managed to move it. Whereupon her arm brought up a bag containing something I knew not what, but I saw that it was living and that it had been weighted down.

Bringing her burden to the shore, she beckoned and called for me to come. I was at her side in a trice. Untying the dripping gunnysack, she rolled it back and revealed its living load . . . Only now did the significance of that lurking twinkle and her consequent caprice become entirely clear. While I had been occupied for over an hour intently bent upon a business whose net result was the finding of two spider-crabs, not uncommon in other parts, but here comparatively rare, she, during various employments among which was preparing the midnight meal, had found time to do some collecting of her own accord and had gathered sixteen specimens of *Hyas* along the water's edge! These were of varying sizes, of different sexes, young and old.

V

Our determination to make a night of it on the bight was strengthened by our further success at wading with the hand-seine. The returning tide, it seemed, had brought in full force the various foraging legions of the sea. With every haul, we found our net filled with fishes, many of them strange and of great interest, some of unusual beauty. Sea-robins, curious finned creatures which crawl as well as swim; the equally curious pipefish, cousin of the sea-horse; killifishes and flounders we caught in hordes. These shore fishes had crept along the rising water's edge to prey upon the little amphipod crustaceans which during low tide remain secreted under shells and stones.

But not all fishes which swam afoul of our seine were peculiar to the shore. Twice we had to tussle with a young swordfish over two feet in length which, after once entangling itself in the meshes, returned soon after, a second time, to take its toll of the numbers we were driving before our net. A sand shark, nearly as long, was another of these hungry prowlers who, under the cover of darkness, make their raids upon the weaker population of the shore. This creature, upon finding itself corralled and gradually veered toward the land, virtually lost its head as well as its voracious appetite; it became seized with a sudden panic and raced around frantically, trying to find some avenue of escape. Whereupon we set up a great show of splashing—my Faithful Assistant at one end of the long seine and I at the other—to prevent its getting away. We did this purely from the sheer determination to catch it, having no intention to keep or to harm it even if or after it was ours. But the little shark, being evidently as determined as ourselves, in a desperate effort leaped clear from the water and fell on the seaward side of the floats supporting our seine, disappearing at once to be seen no more.

However, apart from their passing interest, fishes engaged us not at all; our chief interest was centered upon the crustaceans which we found among the contents of the landed net. Fortune had been uncommonly kind. Beside a goodly assortment of such as lady- or spotted-crabs, green-crabs, rock-crabs, mud-crabs and hermit-crabs, more *Hyases* came our way.

Indeed, I had now obtained more than were sufficient for my intended purposes of study and experiment. I was able to select only such as were suited to my needs; it was not necessary here to content myself with decrepits and cripples—which the hazards of collecting not uncommonly compel —and I chose only specimens of worth. Among these were the pair I found first. The male was easily the largest of the catch.

For some inexplicable reason, a migration of these spider-crabs had been in progress. Whether the *Hyas* horde had left their usual haunts because of a biological urge or of some cataclysmical submarine event was impossible, from this limited observation, even vaguely to surmise. I do no more than merely state the fact of this occurrence. I cannot explain it. Never since have I seen them in such numbers.

Night, however, eventually nearing the end, marked a gradual diminution in the numbers of the spider-crabs and in those of the other transient multitudes which had sought the shallows of the shore. But I had been so absorbed by the business of the expedition that my first intimation of impending dawn did not come until a starling's song was wafted to my ears. Only then did we call it what it was, so to speak—a night's work—and decide to go home.

After loading our little boat with our collection of animals and our paraphernalia, we covered with sand the dying embers of our fire, and finally pulled away from the shore. The moon, now pale and grown larger, was approaching the hilltops just appearing along the horizon in the West. In the East was a grayish glow—soon completely to dissolve the already fading stars of the summer night.

The time of year notwithstanding, the morning air was chill. And when we reached the *Hippocampus*, everything was cold to the touch, and her decks were dripping with the dew. Ourselves being already wet from the work along the beach, we repaired at once to the warmth and comfort of the cabin where we were soon sipping some steaming hot coffee and contentedly discussing the events of the night, with an occasional side-glance at the port-holes to see what progress the sun had made.

My physical make-up must be peculiarly different from that of others. For I am so constituted that the idea of sleep would seldom occur to me were it not for some other fact than that which alone has to do with bodily needs. Realizing, then, that this wakefulness of mine was not shared by my Faithful Assistant, I suggested that she turn in to get her required rest. To this she at first demurred. But the demands of Nature could not much longer be denied, and shortly after she was on her bunk, saturated with salt-water, but, none the less, sunk in a sweet and profound sleep. Whereupon I went out upon deck and raised the anchor.

Soon the *Hippocampus* was headed toward Hempstead Harbor. Her speed was much moderated, however, for I had decided to learn what luck would attend the lowering, at the stern, of the tow-net and trawl. The tow-net, let me say, is for trailing at the surface for microscopic plankton; it is a long muslin funnel held open at the larger end by a wooden hoop two feet in diameter, while at the smaller end is tied a common wide-mouth pickle bottle to receive the minute material caught by the trailing cone. The trawl, although a device subserving the same purpose for larger animals, is of a different pattern; this is a great meshed bag, twenty or more feet in length; it is attached at the mouth to a slender six-foot beam, and this in turn is supported on iron sled-like runners which at the end of a cable are dragged along the bottom. The latter collecting appliance I now used in lieu of the dredge—a similar apparatus but so constructed that a steel scraper scooped up the superstratum and its living inhabitants, both fixed and free, from the floor—because of its easier operation single-handed, though quantitatively the results with the dredge would have been surer.

The tow-net was allowed to take care of itself, requiring no other attention than an occasional hauling-in to transfer the cloudy contents of the bottle to a large collecting-jar: but the trawl was not so free. It needed constant watching lest upon its striking some submerged rock or reefy snag the propeller should not be stopped soon enough to relieve the strain and to avoid a serious tear or perhaps its entire loss. Indeed, this vigilance eventually was well rewarded in another, but a quite unanticipated, way.

Having just rounded Prospect Point, which marks the easterly tip of Manhasset Neck, the *Hippocampus* was on the last leg of her homeward course. Hempstead Harbor, with its fleet of summer craft riding at anchor behind the breakwater, hove into view. The sun, now risen, began to dispel the chill and dampness remaining from the dewy dawn. We were passing over what I had known to be, from the charts and from previous soundings of my own, a depth of over fifty feet with a bottom composed of soft and sandy mud. Feeling secure in my knowledge of the floor I accelerated slightly the speed of the boat. She was running easily, holding to the course with but an occasional turn of the wheel, when with a sudden creaking groan, the already taut towing cable tightened still more around the stern bitt; for an instant she hesitated; at the same instant my hand was on the lever and threw out the clutch. The trawl had struck. But from the continued momentum of the moving boat, it appeared that the obstruction was cleared. This was an error, however, and it soon became manifest. On attempting to proceed under power, the boat labored; then I knew that whatever it was we encountered had been torn loose from the bottom and was being carried along by the net. I closed the throttle and brought the *Hippocampus* to a stop.

The shock of this contact, although slightly transmitted to the boat, owing to the elasticity of the two hundred feet of cable, was enough, nevertheless, to awaken my Faithful Assistant. With our combined efforts we soon had the trawl with its unknown freight on the way to the surface.

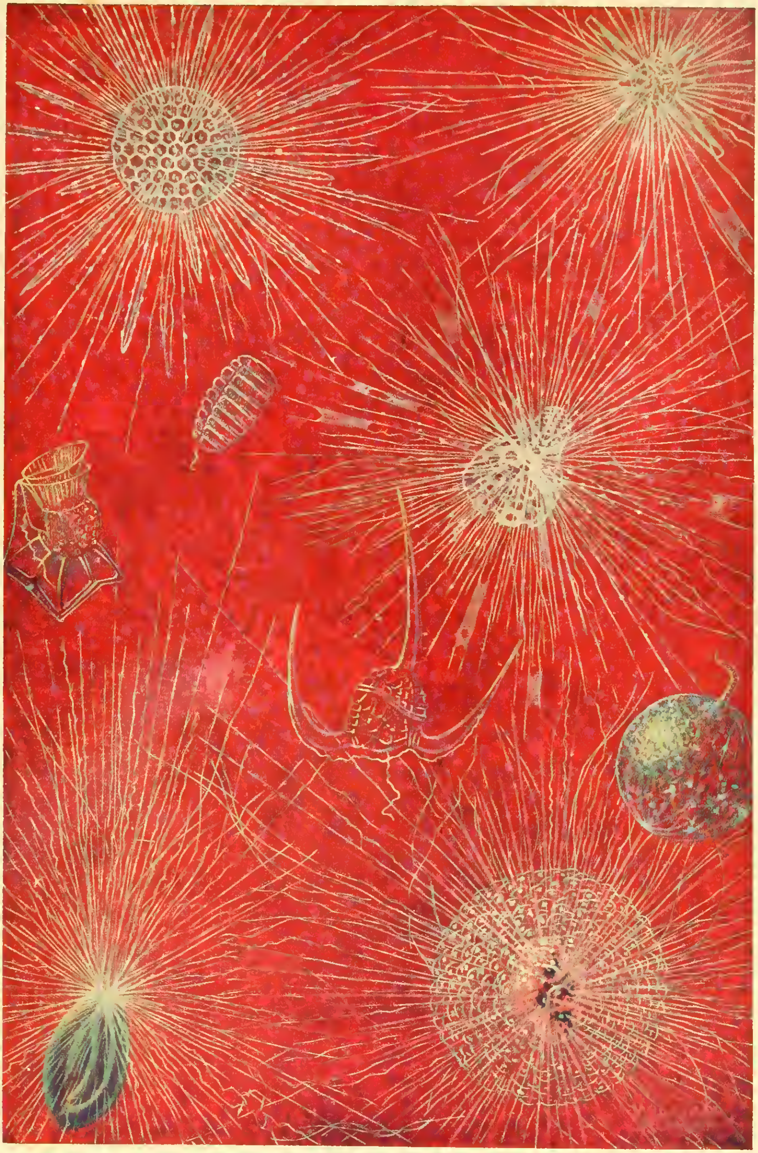
But before it reached our level, it became gradually visible in the transparent depths below. It was burdened with nothing more exciting than a weed-covered, worm-eaten, and water-logged plank. This, from all appearances, was ripped from the side of a submerged and crumbling wreck; it was broken off abruptly at one end and had become wedged between the iron skids at the opening of the traveling trawl. The interior of the net contained several squids, some fishes, and a seething mass of different species of crabs—*Hyas* being the most abundant.

After the trawl was secured close to the side, my Faithful Assistant left me to myself, where I was looking over the population of the plank, while she went into the cabin, whence soon the odor of frying bacon was wafted over the fresh morning air.

As is usual with timber long submerged, the plank had become a haven for a horde of smaller folk such as young starfishes, baby crabs, and various species of the lower, long-bodied crustaceans, and of worms. Permanently attached were sundry plants (red, brown, and green seaweeds) and

LIVING JEWELS OF THE SEA (MAGNIFIED)

Heliosphaera: a radiolarian (upper-left)
Amphilonche: a radiolarian (top-right)
Eucyrtidium: a radiolarian (middle-right)
Polykrikos: a dinoflagellate (upper-middle)
Ornithoceras: a dinoflagellate (middle-left)
Ceratium: a dinoflagellate (lower-middle)
Noctiluca: a dinoflagellate (lower-right)
Quinqueloculina: a foraminifer (bottom-left)
Globigerina: a foraminifer (bottom-right)



LIVING JEWELS OF THE SEA

plant-like animal forms (hydroids, sponges, and anemones).

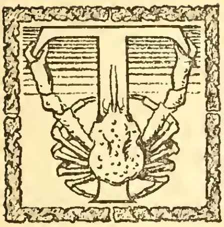
I will not impose upon the reader by enumerating in detail all that I found either in the trawl or on the rotten plank; although giving substance to my narrative, its telling would add nothing to the interest of the plot. There are a few things, however, that cannot be so ignored—of which more than mere mention must be made. For their significance is such that had not their finding come to pass, all that precedes in this chapter would never have been told, as those events were but the prelude to this most important end—an end, in a way, which was really a beginning; for, at the close of that memorable night, started my first sustained inquiries into the lives and habits of those four forms to whom the concluding part of this work will be more or less devoted; each of which, it may well be said, is in its own way not surpassed in surprising interest by any other groups of animals in the sea. I mean the spider-crabs, the sea-horses, the squids, and the disk, or scyphozoan, jellyfishes.

In sum, for such a start, the trawl furnished fitting material. In the net were contained three female *Hyases* burdened with eggs, and several hippocampids, one of which was a male, bearing in his pouch a number of young. On the plank, attached to a clump of red, hair-like seaweed I came upon a cluster of finger-shaped cocoons containing the eggs of a squid; also I found fixed to the wood a group of tiny flower-like forms, the larvæ of *Aurelia*, the beautiful moon-jelly.

CHAPTER SEVEN

Hyas: A Monograph of the Spider-Crab

I



THE title of this paper could with almost equal appropriateness be substituted with the single word "Jim." This was the name of the spider-crab who, more than any other individual of his species (*Hyas coarctatus*), helped me to make such modest discoveries as I shall have occasion to describe in this history of his kind.

We called him "Jim" from the start. He, with other recent spider-crabs, had not been long in my largest tank when my children, apprised by his superior endowments, marked him by name from all the rest. Although young—a silver quarter would cover his carapace—he was a good fighter, a most excellent thief; with charming adroitness, he could filch a portion of another's ornamental property or snatch away its food, with equal finesse. This tendency affectionately to apply pet names to the creatures of my laboratory has sometimes served, so to speak, a double purpose of identification. Not seldom have I learned through the eyes of others how "Maggie," "Hank," "King Tut," or "Bimbo"—meaning respectively some turtle, hermit-crab, fish, or sea-worm of personality—revealed another singularity of trait or habit while I had been occupied elsewhere.

Thus, in this manner, upon my return one evening from a three-day cruise of observation along the Sound, I was solemnly apprised that Jim had taken sick. He had refused all of their proffered food; his aggressiveness was gone, and he spent the entire time sulking in the darkest corner of the tank.

Followed by my anxious family, I straightway went into the laboratory to see for myself the cause of their concern. It was true, as they had told me, he was lethargic; but I had my own suspicions as to whether he was really sick. Not wishing, however, to raise false hope—for I was not *too* certain myself—I said nothing, but I set about to seek the meaning of it all. This meaning I finally found. As the evening wore on, I continued to watch. And long after the rest of the family had gone to bed, I was rewarded with what to me is a common but an ever engaging sight. The shell of the crab began to split around the sides and across the segment of its reflexed belly where it joins the back —positive proof that its apparent illness was only the usual indisposition of all crustaceans preliminary to a molt.

However, before proceeding further with the curious operation wherein the crab was required to accommodate its increasing size by casting off its shell, I must point out that although molting is a normal process, it is not attended without danger to the individual. No period in the life of the crab is more critical; during this delicate process, death frequently results.

Despite the silt and fragments of seaweed which served to mask Jim's back, he was clearly visible through the glass sides of the tank. No doubt, in his natural habitat he would have been inconspicuous to his enemies passing above; but here at eye level this adornment in no wise hid his actions from view; only the top surface of the shell was completely covered, the legs for the most part being bare.

The first indication which he gave that he was about to slough, was a convulsive twitching of his appendages. This was immediately followed by a cracking of the crust. Except for the region of the rostrum, where the eyes and mouth appendages are located at the front, the top of the shell separated from the underpart and legs and began to lift at the rear, opening like the hinged cover of a box. Slowly the crab, with spasmodic tremors of its frame, worked its way backward out of the carapace until it was finally free, and then remained motionless—doubtless exhausted from this travail. The entire operation lasted a little less than half an hour.

Now Jim, prior to shedding his armor, had, like most males of his kind, shown visible evidence of many battles. He was, in fact, maimed when I first found him, having lost one of his rearmost legs. Perfect specimens among spider-crabs are the exception rather than the rule; for generally these creatures are minus one or several appendages. Notwithstanding their sluggish habits, the males particularly are prone to engage in quarrels. Battle-scars and such disfigurations as the loss of a leg, while inconvenient, perhaps, are but temporary, however, and of little moment to the growing crab. This was shown in the case of Jim. When he cast off his old covering he was, in a way of saying, born anew; no trace of his former disability remained, regeneration was complete.

Resting on the floor, he now seemed wan, his paleness being in striking contrast to the drab-black shell he had just abandoned. However, in his weak and defenseless condition, this ghost-like color was obviously a protection, as it seemingly gave him a transparency whereby he was one with his surroundings, rendering him practically invisible to the casual eye. But these were not the only changes in his appearance: his now soft hide was wrinkled and shriveled; and when he eventually did essay to move, I could see his legs bend under even the weight of the water-supported body.

It was five or more minutes that Jim remained immobile. Then he proceeded to dig himself into the sand. This he accomplished by a backward movement; first burying his hind legs, then slowly insinuating his body until with the exception of the tips of his antennæ, he was entirely hidden from sight. Here I left him undisturbed. I knew what would henceforth take place. With the folds of his wrinkled skin filling out, the hide would begin to harden; another day or so would find him active, camouflaged, and armored with a rigid crust.

At this point, I put to myself some pertinent questions. How did the spider-crab contrive to breathe without suffocation in the mud and fine sediment of its natural home? From what I had known of other crabs, whose respiratory processes were the same, sand, by reason of its coarseness, offered no obstacles to their breathing, but finely divided mud made this effort difficult in the extreme. Again, since it was enabled so to survive in such sedimentary surroundings, why did it not do its shedding underneath the protective silt? It was easy to conceive that its encumbrance of seaweed was not the cause; it had merely to detach this in order to sink into the bottom. The answer came when I removed the molt from the bottom of the tank.

Commonly the higher crustaceans have gills in the form of tufts which are borne at the base of each walking leg. In the crabs these brush-like breathing organs are enclosed within the carapace, but the water reaches them through an orifice extending around the hinder border of the carapace and is kept circulating and replenished by the rapid vibration of a pair of scoops, or scaphognathites, at the base of the second pair of jaws. The bailing action of this scoop draws the water over the gills and sends it forth from the mouth region in a constant stream. Nor was the respiratory apparatus of my spider-crab an exception to this. However, in examining the molt, I was struck with the structure of the antennæ—their unusual length and the fact that they had an arrangement of short bristles which, when the feelers were brought together, would form a tube, made me think that here might exist some relation to its manner of breathing.

Such was the fact. But it did not in itself solve the problem. As a rule, the head region in most crabs contains only the exhalant orifices, the water first entering near the attachment of the walking legs. Then, too, the spider-crab, unlike other mud-dwelling crustaceans which carry on their legs a fringe of hairs to filter out the silt, is devoid of any exterior straining device. So, unless the spider-crab is able to reverse the current, so to speak, the tube, it will be seen, only serves to extend its course.

Well, this reversion is exactly what takes place. The spider-crab can alternate the stream, drawing the water down the siphon thus formed to its gill-chambers and discharging it at the rear. And this discovery contained at once an answer to my second question: A *Hyas*, when casting its molt, cannot conceal itself in the sand or mud until its antennæ are sufficiently free to act as an incurrent conveyor tube.

In passing, I must also mention that the period of this molting accords with those of other observations I have made; these crabs, although not invariably, usually molt during the night.

II

When, several days later, I next had opportunity to give my attention to Jim, he had so increased in size that under his debris accumulated on his back, I at first had difficulty in recognizing him among his crab companions in the tank. The crust he had discarded measured about four inches including the legs when these were fully spread;

he was now easily an inch larger, overall, than his hollow shell.

Of all the true crabs, or *Brachyura*, to give them their technical name, the spider-crabs perhaps are the most unprepossessing of the group. And of the spider-crabs, the species *H. coarctatus* would be the last to take a prize for pulchritude. The reader will gain some idea of their claim to beauty when I say that these creatures are more commonly known as "toad-crabs." This, however, is slandering the toad. For a *Hyas*, except for the fact of its warty back, bears little resemblance to that animal, and surely falls far short of even the latter's charms. In truth, it has no likeness to anything living on land; at first sight its thin, long-jointed legs are those of a huge spider, but its body is that of a wrinkled flattened pear. Besides an assemblage of warts, short hairy hooks and bristles and spines are loosely distributed on its back. Some warts and hairs are also strewn along the upper sides and margins of its legs. But let us not linger over the spider-crab's physical portrait; its real personality becomes apparent only by examination into the workings of its brain.

In a corner of my laboratory, away from the direct light of the windows—for the spider-crab is extremely averse to strong light—I prepared a small tank for the reception of Jim. This tank, composed entirely of glass, I covered around the sides and bottom with a thin layer of transparent varnish to which some red dye had been added. A pane of glass large enough to cover the top was similarly treated. As a control tank for the experiment I proposed, I placed alongside the red aquarium, one of the same size but coated with green. Into each was put an equal number of small seaweeds all of an approximate size. The seaweeds, however, were of two kinds, green sea-lettuce (*Ulva lactuca*) and red Irish moss (*Chondrus crispus*), and these were evenly distributed in the two tanks. Thus, the red tank contained an equal amount of red and of green seaweeds; likewise the green container.

Removing Jim from the big aquarium, I stripped from him the material with which he was masked, and cleaned his carapace well; then putting him into the red receptacle, I watched to see how he would react.

The first few moments were marked by a decided uneasiness on his part because of his recent handling and the strangeness of his environment; but soon he settled down and began to give his attention to a little frond of red seaweed. This he seized in his pincer and pulled toward his mouth where it was held while he proceeded to tear it into shreds with both claws. Then, having reduced it to a size which he evidently deemed suitable for his purpose, he whirled and rumpled it in his mouth-parts, or maxillipeds, for a short space; after which he took it in his claw once more and with an awkward flourish brought the plant around over his carapace, catching it on one of the groups of hook-like bristles which grow on the tubercles on his back. Except for an occasional alternation in the claws he employed for the purpose, this masking performance kept up without variation for nearly an hour, at the end of which time he had completely covered his carapace. Always were his rumplings and flourishings the same; and—what is peculiarly to the point—always was a seaweed selected which was of the same color as the environment.

Nor is the crab's choice of color restricted to red alone. Denuded of his covering of Irish moss, and placed in the control tank, Jim after another momentary spell of nervousness once more began to garb himself, but this time entirely in vegetation of green.

In truth, except for a seeming indifference to black, the spider-crab can distinguish all hues; for (as I later found in my experiments with these creatures) with the exception just noted, regardless of the color of their environment—red, green, blue, brown or orange—they unerringly select materials at their disposal, whether it be paper rags or plants, which will more nearly match.

Moreover, in a tank evenly divided in halves of a different color such as red and green, crabs already clothed in one or the other of the corresponding colors when transferred to this aquarium will make their way toward the region harmonizing with the hue of their coat. That is to say, the red crabs seek the red end of a red-green tank while the green crabs move toward the green.

But here arises a surprising thing, if we consider the foregoing results of experiment as a striking manifestation of a marvelous instinct: A red crab when put into a green aquarium will not rid itself of its conspicuous panoply, nor, likewise, will a green crab when placed in surroundings of red—both, however, will continue to add to their habiliments only such materials as do not contrast with the prevailing hue of the tank.

More surprising still, in a black environment strewn with materials of every color, they invariably choose not black but any of the other colors, oftentimes the brightest, thus becoming conspicuous rather than concealed—defeating the primary purpose of camouflage.

These facts are significant of but one thing: the spider-crab's mimetic behavior is not the result of higher reason but of unconscious rote, a fundamental reflex arising out of the past experiences of the race.

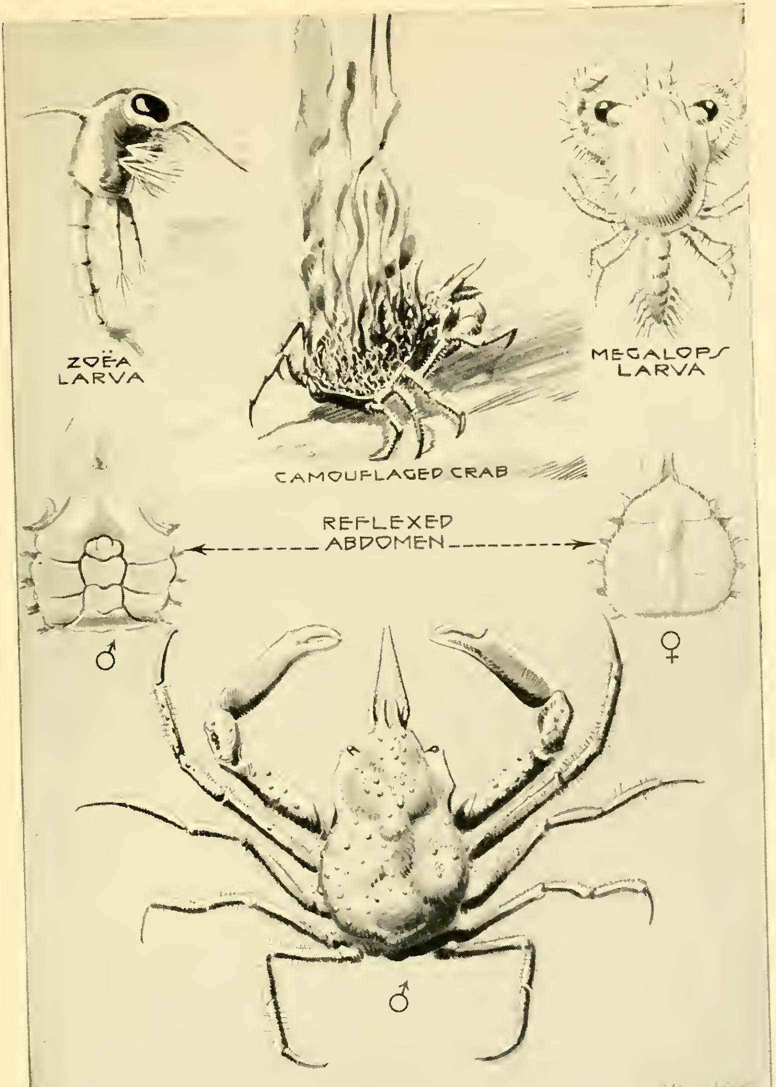
That all intelligence, whether it be that of man or beast, is a reflex manifestation, there seems to be little doubt. But it is equally transparent that such intelligence, even by the most mechanistic interpretation, must at bottom long remain a mystery. The real nature of the factors which have to do with the operations of the mind cannot be even remotely comprehended. Again it is clear that regardless of the degree of a lower animal's intelligence, its kind, or quality, may be quite different from that of an animal higher in scale. For this reason alone human interpretations of intelligence in arthropods are apt to err; judging their actions from the human standpoint, we are prone to put behind them human personalities. Consequently, to fathom what passes for the mind of a crustacean, should seem to be beyond all bounds of possibility.

Yet this very thing *is* possible—but only because reason, as this property is commonly conceived, is not part of the equipment of the crab. In short, intelligence, as such, has little to do with that which has long been held as the primary proof of this capacity in the crab: that is to say, concealment by the choice of colors in camouflage.

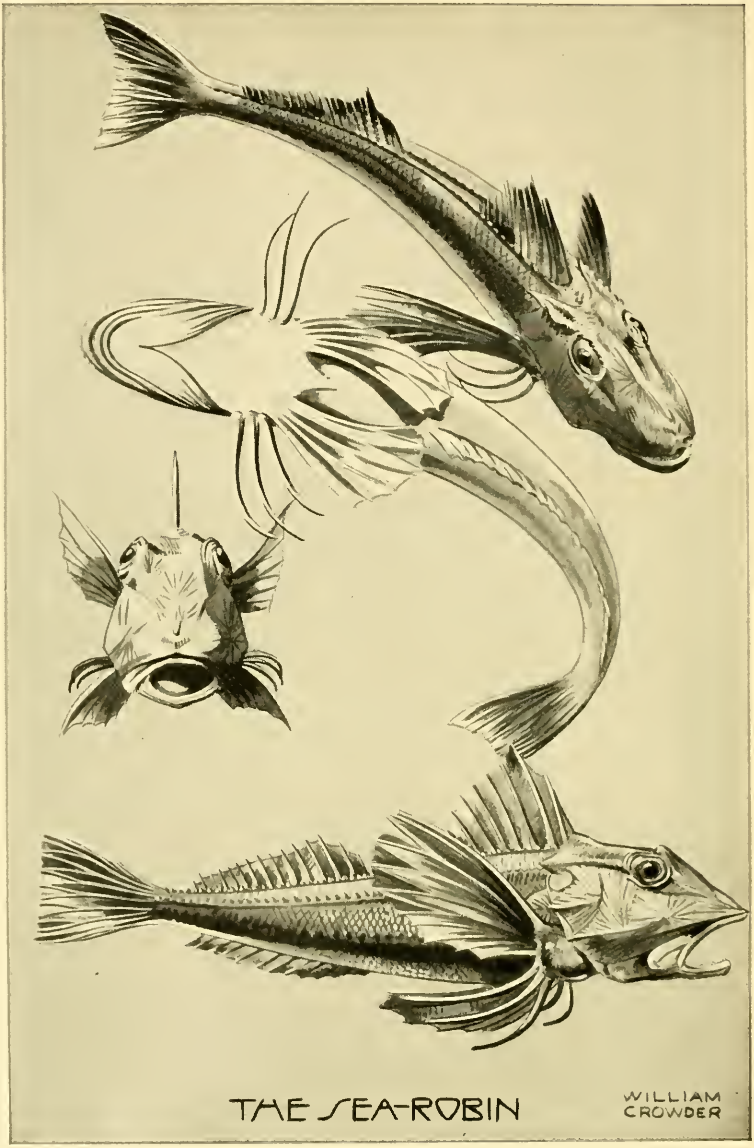
Evidence of this, I think, will be amply revealed in what follows.

III

Thus far the procedure of my experiments had not departed greatly from that of other research workers whose literature had thrown such luster on this crustacean. But if my methods and the immediate results therefrom lacked originality, the conclusions I formed regarding them were novel. My previous faith in the famed and superior mentality of the spider-crab began to give way to


ZOËA LARVA
CAMOUFLAGED CRAB
MEGALOPS LARVA
REFLEXED ABDOMEN
♂
♀
♂

THE SPIDER-CRAB



THE SEA-ROBIN

WILLIAM
CROWDER

doubt. If the findings of others were all that the publicity and exploitation of these implied, what explanation could be given to those errors of judgment in the crab wherein it defeats the purpose of concealment in assuming a gaudy disguise? Indeed, this aberration is more than a mental mistake—it is an error of instinct (if we grant that so fundamental an attribute exists apart from the higher operations of the mind). And yet, even so, ascribing whatever terms we will to the psychism of a crab, is it not possible to explain these errors in more material terms as well? So, at least, it seemed to me. The idea that such vagaries of behavior were due to the independent functioning of the brain, did not appeal to me. I was decided to trace a more tangible cause.

But exactly how? The only obvious way open toward this end was through mutilation—I would be obliged to operate upon a spider-crab and remove the brain—a procedure I was ill inclined to carry out, and then only as a last resort.

Let me say here, I am not an anti-vivisectionist. I am convinced of the necessity for experimental work upon living animals. This necessity, particularly in pathological research, is so patent that its defense by me would simply be a waste of words. But I also believe that much needless butchering has been perpetrated in the name of science. Like the enterprise of so-called "scientific collectors," experimentation is to many nothing more than a species of hobby—a pursuit wherein the fascination lies not in the acquiring of solid learning but in the translating of tortures into graphs and curves; which is to say, recording by the means of pretty plots on paper the unimportant fact that the stumps of a hermit-crab's amputated eye-stalks will grow new cornea-lenses, or that the pigment cells of a flayed squid will respond to light. To such length has the madness of these devotees carried them in their destructive diversions that they have completely lost the significance of research, which is to make methods in experimentation a *means* of obtaining higher knowledge, and not the *end*. Their frenzy, in fine, seems to have little in common with the true spirit of scientific investigation. It is more of a sort allied with a zeal that would have discredited even that of those who inspired the cruelties of a darker age—the Spanish Inquisition was above slaughter solely for slaughter's sake . . .

To say that a lower animal such as a crab cannot suffer pain, is to utter nonsense. Still this superstition does prevail, even among some in whom, by their learning and attainments, one might expect maturer convictions. Pain is the alarm signal of the organism. It is through this medium that danger to the tissues is apprehended. However, from what is known of the functions of the nervous system in invertebrates, it is not unlikely that the more lowly organized is the creature, the less sensitive it is to those injuries that cause pain in man and other mammals. Thus a worm or crustacean will probably suffer less than a human who is also constituted so that his suffering is accompanied by an intense psychic disturbance. Moreover, the purpose of pain being a warning, its presence in any creature would seem to be in proportion to that creature's power of regeneration. In other words, a primitive creature such as can grow new organs or other parts with facility is less likely to feel physical pain than higher animals not so endowed. To a starfish or a sea-anemone, both of which have a low nervous system, it is of little consequence to be cut completely in two: such an injury to the more highly organized crab is instantly fatal—even the cutting off of an eye-stalk (a regenerable appendage) will sometimes produce a surgical shock sufficient to kill within a minute's time. So it is not inconceivable that any creature equipped with nerves is, to some degree at least, capable of suffering pain.

Now all this is not to say that I am opposed to every investigation that requires the infliction of pain. The point I am trying to make is that much unnecessary suffering is caused by puerilities that pass as scientific research. Indeed, candor compels me to add that I, myself, have not always been entirely guiltless of sharing in one phase of this unholy enterprise. Time was when, in the belief that this glorified butchery was part of the making of a naturalist, I slew and slew and slew. But that vain delusion is no more. With growing experience in my trade there gradually came the conviction that these employments were not only causing considerable sacrifice of precious life but also they were a sinful waste of time. Human nature and human ways certainly could not be studied in the corpse; neither could traits and capacities be learned from the carcass of a jellyfish or crab. Therefore, I devoted my attentions more and more to such essentials as can be found only in the living, rather than to details of doubtful value in dissections of the dead. In these latter years, although I will as readily as ever kill any creature that I think will serve my purpose for study, my ideas as to what constitutes such a necessity have considerably altered. Before I am moved to take the life of even the humblest form, my motive must be more urgent than the wish to satisfy an inquiring whim—it may be inquisitiveness, perhaps, but never mere curiosity.

Was my desire to learn the underlying reason for the spider-crab's disguise a sufficient motive to maim a living *Hyas?* I believe it was. There was more at the bottom of this masking performance than so simple an act would seem to imply. If my suspicion of this perplexing puzzle could be proved, I saw that it would open up a vista through which even an aspect of human behavior might be viewed. In any event, operative measures on my part were not wholly needed to achieve this end. I was saved from the necessity of undertaking the disagreeable part of my experiment by the subjects themselves.

Six or eight weeks after the molting which I have described, Jim gave signs that he was about to repeat the process of casting his crust. In his normal habitat, the sea, it is not likely that he would have molted so soon; for this is a growth phenomenon, and the supply of food promoting this end is not so abundant there as in my tanks. Confined in the same quarters with Jim were several other spider-crabs of varying sizes; however, he was the smallest of the group. Now I have before observed that he was a good fighter; but the time of molting is a period of weakness, and during the night (probably at the precise time he slipped out of his old armor, soft and defenseless) he was set upon by the other inmates and nearly killed. Three of his walking legs were torn from his body, and one great claw was gone; but the most serious injury he received was a huge rent in his carapace, a deep gash on the under side in the region of the brain.

It was in this frightful condition that I found him on the morning following the treacherous attack. I was for despatching him at once. And as I set about to prepare an anæsthetic for this purpose, came the thought that by a different procedure other ends as well as those of mercy might be served. So from my cabinet of instruments I selected a sharp knife having a needle-like blade with a recurved point. This keen hook I introduced into the gaping wound on the under part of the shell, and with a single stroke severed the two nerve trunks communicating between the subesophageal ganglion and the brain. The result of this operation was practically to isolate the brain. With its connectives cut, this organ was rendered as useless as if it had been removed from the body. All consciousness was completely gone; whatever movements the crab would now exhibit would be the sole result of reflex.

To say nothing of the shock of such an operation during so delicate a period, it should seem that Jim could not survive by many hours the mangling he had received on the casting of his molt. Yet two days later when I looked into the small tank into which I had placed him by himself, he was still alive. Indeed, there were signs of returning strength; his shell had hardened; he had moved from the spot where he was put. Nor was this all. He had made some attempt to disguise himself. For attached to the margin of his carapace, I found a slender raveling of seaweed—a crumpled fragment, but obviously a piece he had torn from one of the anchored plants.

Other events were not long delayed: on the same day of this amazing discovery, I was the actual witness to its masking maneuvers. I saw it clean itself, go over its hooks and walking legs with its claws, and further disguise itself in the same manner and order of movements that were employed in its normal condition. In short, during the remainder of his life—which lasted three weeks more—Jim, deprived of his brain, did not betray any other abnormal condition beyond blindness. He ate, walked, and even fought fairly well; but he could not see; his choice of camouflaging materials was made only by physical contact—which is to say, through touch.

But to say that the sense of touch was the means of his capacity for camouflaging, is to name and not explain. Beneath these physical manifestations lay the factor of instinct. And, as we have seen, that the instinctive phenomena as expressed by the physical actions can take place without the coöperation of the brain, the implication is that the spider-crab's famous intelligence in this connection is a fiction. Its choice of colors, as well as all other of its self-concealing traits, is but a type of behavioristic reflex. For deprived of its sight, it completes its masking operations when coming into contact with otherwise suitable material, without regard to whether the color of this material may be detrimental or not.

Indeed, it is prone to err in this matter of color choice while in possession of its full faculties and its vision. An instance of this has already been given in my reference to its reaction to a black tank. Thus, experiment establishes that, at least as far as the spider-crab is concerned, instinct is not a function confined to the brain; that it is perhaps in some way a part, process, or product of the whole nervous system, not requiring the complete coördination for its normal operation; and that its ultimate logical interpretation can be only in chemico-physical terms—that is to say, it is a reflexive response of the anterior region and its appendages, a response partly through the chemoperceptions of the mouthparts, partly through the photoperceptions of the eyes, and partly through the tangoperceptions of the claws and dorsal hairs, or hooks. This, translated into less technical speech, means simply that the instinct of self-concealment is a series of automatic actions induced through taste, sight, and touch.

The question yet remains: Whence arises so fallible an instinct? At best, the spider-crab's efforts at self-concealment would seem to result in no decided advantage to the individual or the species. Surely no apparent necessity for camouflage exists in its natural habitat which is in the deeper water —a region of gloom.

The answer is doubtless to be found in its past. It is more than probable that the ancestors of the spider-crabs—and for that matter all dwellers of the deeper waters and the abysses of the sea—inhabited the sunlit shallows close to the shore. In times past the conditions were not unlikely the same as those prevailing in this area now. The dense population made competition exceedingly keen. Everything edible, living and dead, had scores of ready devourers. In a sense, one half of the population subsisted upon the other half; therefore, the better to avoid serving as food as well as to obtain it for themselves, certain creatures learned to simulate their surroundings, some developed swiftness of movement or unusual strength, while still others resorted to actual concealment, or hiding. Yet, notwithstanding these devices and the enormous prolificacy that obtained, the balance of life was maintained at a critical point. In this mighty struggle for existence, the welfare of many species was entirely dependent on some feature of form or color.

Still, even these devices in numerous cases were not sufficient to enable their possessors to hold their own in the stifling competition that raged along the shore; and many of these were crowded into the deeper regions or took to these of their own accord; the rest became extinct.

That the spider-crab is such an exile, is only too plain. Its masking habit clearly indicates its origin. This habit, now useless, arises from an instinct, a reflex, inherited from ancestors who, living under conditions quite dissimilar, doubtless then derived from it a direct advantage.

IV

The foregoing experiments were carried out in a somewhat desultory manner during the summer months succeeding the discovery of these remarkable creatures on the occasion of the nocturnal episode described in the preceding chapter. However, in the meantime I began upon an inquiry of another kind. This was with regard to those details of their life history that had to do with development and with habits other than that concerned with disguise. It is now a goodly number of years since these investigations started; and it is only now, at the time of this writing, that I may properly be said to have brought them to a satisfactory conclusion. But it is most eminently proper to add that this could not have been so readily accomplished had it not been for the invaluable help I received from a crab called "Little Jim"—so named, when hatched, for the creature whose contribution to natural history we have just recorded. This crustacean at the present moment of writing is alive and vigorous; if good feeding, a capacious and well-balanced aquarium, and my household's affectionate care are conducive to these ends, it is likely so to remain for many months to come.

But first before dealing with this spider-crab, let me, for the further sake of this record, set forth the following facts: The mother of our Little Jim was collected together with its father. The last molting of the female is the time of her marriage. During this delicate period, she finds protection for her defenseless body not by hiding in the bottom, but under the shielding bosom of her hard-shelled mate. Often prior to such molting, she is carried about by him, after which—while she is still in the soft-shelled stage—fertilization is effected. The copulative embrace lasts for a couple of days. Indeed, so tenacious was the male's hold on the female when these were taken that even the experience of the trawl and the subsequent transference to my tanks failed to disturb their attention. On this occasion—the only instance in the lifetime of the female wherein devolves upon her this biological function of her sex—her sperm sacs become sufficiently filled to fertilize all the eggs she will lay during the remainder of her days. The eggs are not fertilized while they are still retained in the ovaries; they meet with the male element as they pass through the sperm sacs when leaving the ovaries for the exterior, at the time of spawning. If mating occurs very early in summer, it is possible for her to have a clutch before autumn; however, the season of mating is usually in late July or early August and the eggs are then not laid until late in the following spring or in the summer. During the course of her life, subsequent to this single copulation, the female spawns twice—in some cases probably oftener. Soon after the last batch of eggs are laid, she dies.

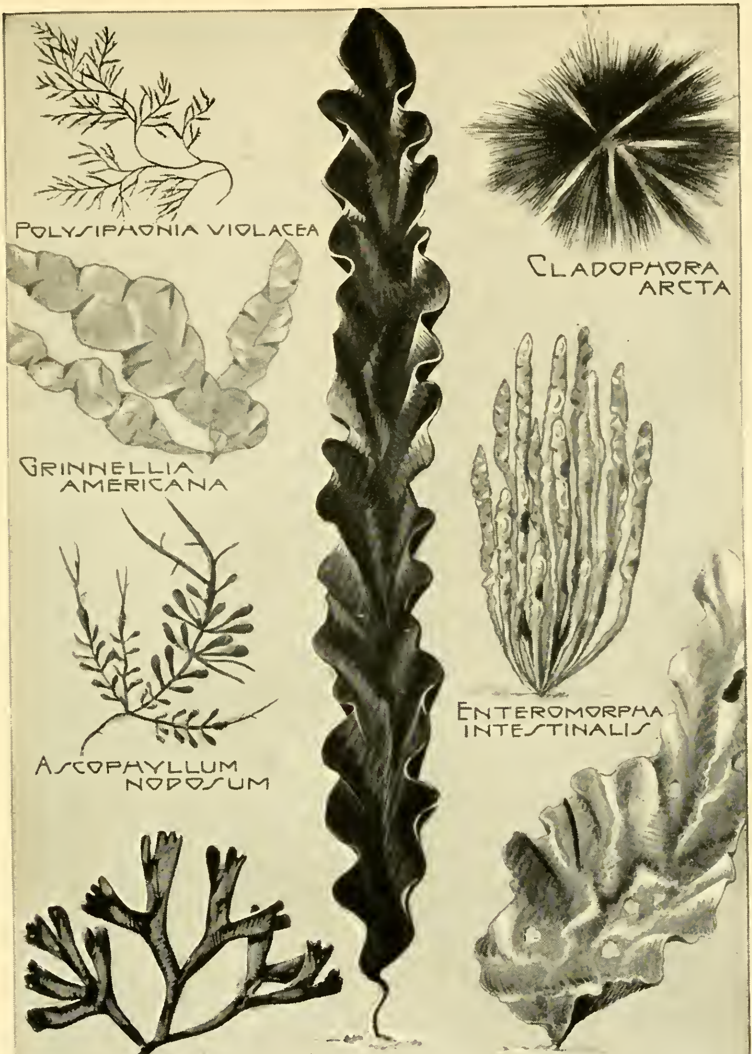
It is to be observed, therefore, that it was not until a year after I caught its parents that "Little Jim" appeared upon the scene. For a fortnight previous to actual hatching, however, it had been carried about while still in the egg together with upwards of a million brothers and sisters attached to the swimmerets of the mother. The swimmerets compose an external, branched hairy process on the under side of the mother's reflexed flat abdomen, upon which the eggs—each egg no larger than the period ending this sentence, and each attached to a hair by a short tendril-like stem—are clustered like an enormous compact bunch of tiny grapes. When first extruded the mass was of a light ochrous color; later at the time of hatching it had become a brownish black. It was at this period of incubation that I detached Little Jim with several other embryonic crabs from the swimmerets and placed it together with its unhatched companions in a shallow dish of clean sea-water.

In this receptacle, under the binoculars, the course of its future development could be followed with ease. Minute as it was, measuring less than a hundredth of an inch in diameter, it was singled out from the others at the start because of its slightly larger size. Seen under the microscope, the egg-membrane was so opaque that it obscured the details within; but two great black blotches were visible near the surface, indicating the position of the growing embryo's eyes. Two days after this transference, which is to say twelve days after being laid, the eggs hatched. It was during the night when the liberation actually occurred; and Little Jim, now easily the largest of the larval brood, was found swimming lustily around the dish on the following morning . . . Also, the great egg mass which the mother had been carrying on her swimmerets, tucked tight under her shielding abdominal flap, was now no more. A cloudy swarm of microscopic moving forms on that side of her tank which was nearest to the light, gave witness to why her burden had disappeared.

Certainly no one unfamiliar with these larval offspring would ever recognize in Little Jim a relation of the adult spider-crab. In general its body was long and cylindrical; it measured about one twenty-fifth of an inch in length. It was marked by two distinct regions: a relatively large forebody, a fusion of the head and thorax, and a slender segmented hindbody. On each side of the forebody at the front was a great compound eye. The color of these organs alone, aside from their size, would have made them conspicuous; their intense blackness contrasting sharply against the opalescent transparency of the body. A long sharp beak projected forward from between the eyes; from the middle of the back arose an enormous spine; while midway on each side of the thorax jutted out a smaller spine. Besides two pairs of bristle-bearing antennæ, the forebody carried four pairs of leg-like appendages. The larva swam backward by rapid jerks of its flexible belly, at the end of which was a forked fin, or tail.

It may be mentioned that in this stage of the spider-crab's life it is known as the *zoea;* and the description I have given applies equally as well to the new-hatched young of all true crabs, or *Brachyura*, as it does to Little Jim.

In the course of a couple of days Little Jim had increased in size; but it was obvious that this increase was achieved only after the manner of the


POLYSIPHONIA VIOLACEA
CLADOPHORA ARCTA
GRINNELLIA AMERICANA
ENTEROMORPHA INTESTINALIS
ASCOPHYLLUM NODOSUM
FUCUS VESICULOSIS
LAMINARIA SP.
ULVA LACTUCA

SEAWEEDS

WILLIAM CROWDER

HAULING IN THE TOW-NET DURING A RAINSTORM

EXAMINING THE TOW-NET CATCH

adult—because of a capacity to molt. With each casting of the larval skin, the young crab also assumed a slightly different shape, a shape approaching that of the *megalops*, the well-known form which marks the succeeding stage. I say "well-known" because it was this peculiar crab form when first discovered living free that deceived the systematists into thinking it was a new-found group of crustaceans, and gave it a generic name. It was only after some enterprising naturalist sought to keep a watch on its development that its identity was learned.

Owing to the necessity for frequent changes of water to keep wholesome the dish containing Little Jim, the exact number of moltings was difficult to trace. It is probable, however, that these were fewer than six. That individual progress might more easily be followed, I had early removed its companions to another receptacle, leaving the larva alone in the dish; thus, by the end of two weeks, I had found four discarded skins which I could positively identify as coming from Little Jim.

In three weeks' time it had become a true *megalops*. Now, curiously, in this second stage, it had actually decreased slightly in body length, but it had become enormously broad. Also, it more nearly resembled the adult, having now a somewhat flattened forebody and an abdomen much shorter and wider than that which obtained in the *zoea* stage. The abdomen, however, was not, as in the case of the adult, curled under the forebody, but stood out straight behind. The eyes were still prominent, though mounted on heavy stalks; and it was possessed of ten legs, the two foremost of which were the stoutest and were armed with claws. In fine, our little *megalops* was now so fashioned that it could either swim or walk.

Another week passed. Meanwhile, unlike the *zoea*, no growth took place and no moltings marked the development of the *megalopean* crab. Then, just four weeks to a day after hatching, came a transformation—came a change as complete as it was sudden: Little Jim cast the last remnant of larval clothing and stood forth on its own as a very tiny but nevertheless a perfect spider-crab . . .

Indeed, when I made my routine rounds of inspection on the morning following his final metamorphosis, I missed the little creature; I thought at first that he was lost; but no, there he was, crawling around over the sprinkling of sand in his saucer, with an accumulation of debris already covering his diminutive back.

V

Doubtless the discerning reader has been wondering how it has been possible for me to indicate the sex in so young a crustacean of this kind, how I could so confidently apply a masculine name to an organism in which sex-identity has not yet appeared. Well, the truth is, I have been maintaining a sort of fiction; sex differentiation does not occur in the larva; but owing to a customary habit in my household of giving to undetermined or neuter animals such names as only are applied to males, Little Jim was so called from the start. But now I am obliged to make the embarrassing admission that in the present case if we were not actually presumptuous we at least were premature. For later "Little Jim" proved to be a "Little Lena."

"Big Lena" would be perhaps the apter term, to-day. Since the time, two years ago, when her sex was discovered and a hurried change in name was made, she has achieved her normal adult size. Notwithstanding, she still bears the appellation of her early youth, the diminutive "Little Lena." Nor has she lost the affectionate interest with which we regarded her behavior in her younger days. In fact, already I begin to anticipate with some uneasiness that time when the relation of this dumb creature to my family will be only too keenly comprehended. The span of the spider-crab's life does not extend much over three years; fully two of Little Lena's probable three have passed. As every one knows who has formed an attachment for some shorter-lived friend, time in these matters has not the habit of halting. It will not, therefore, be many more months before the members of the family will note Little Lena's absence from her familiar place of patient waiting—and they will know that their humble pet is dead.

But of Little Lena's overtures toward the attentions of her human friends, I shall presently have more to say. For the moment I wish to resume my thread and speak of certain physical details regarding the identity of the spider-crab's sex. As evidenced in the instance of Little Lena, the female spider-crab, after leaving the *megalops* stage, molts twelve times before she reaches maturity. The indications are also that this number of molts is the same in the case of the male. Now I have before me as I write, not only the dozen crusts cast by Little Lena during the course of her life—all of which are arranged in graduating sequence from the first shell no larger overall than the diameter of a pin-head, to the final sloughing measuring more than two inches along the greatest length of its carapace—but also a collection of male shells representing the different stages of growth. An examination of these latter molts discloses that the abdomen of the male, from the time of leaving the *megalops* form, assumes a shape which remains unchanged the remainder of his life. This shape is characteristic in all male crabs of whatever species, and is roughly like that of an inverted capital T [⊥], when the animal is laid upon its back and viewed from the rear. The hinge, or line of attachment, is at the bottom, the broad and horizontal base; although normally held close to the body, the vertical portion is free; it is a narrow flap which rests in a sort of groove or recess along the middle of the under side.

When the female leaves the *megalops* stage, her abdomen is broad at the base of attachment, but instead of suddenly narrowing, it tapers more gradually to a point. As in the case of the male, this portion of her reflexed hindbody lies in a depression underneath, fitting so snugly that it forms an even surface with that of the forebody. As I have previously indicated, the claws of the female are smaller than those of the male; but as these are sometimes missing, and often of variable size even in the males (owing to regeneration), the shape and width of the abdomen offer a ready means by which to distinguish an individual's sex.

My series of molts tells me something else; it tells me that the tapering form of the young female's abdomen persists throughout her successive sloughing until her adult form is reached, whereupon it becomes a broad semicircular expanse, a great apron almost completely covering the region that lies posterior to the mouth. It is also considerably thickened; no longer lying flush within the depression of the forebody, its surface is elevated, conspicuous, and its border is fringed with hairs.

And here, it should be added, is another curious change: the abdomen previous to its last form is bare and, except for the transverse lines marking the constrictions between the segments, smooth as ivory; after the final molt it bears, like the crab's back, a sprinkling of bristles and hooked hairs. The reason for this is plain when we consider the fact that oftentimes the female is so loaded with eggs that the mass is sufficient to push back her abdominal flap almost in a line with the back.

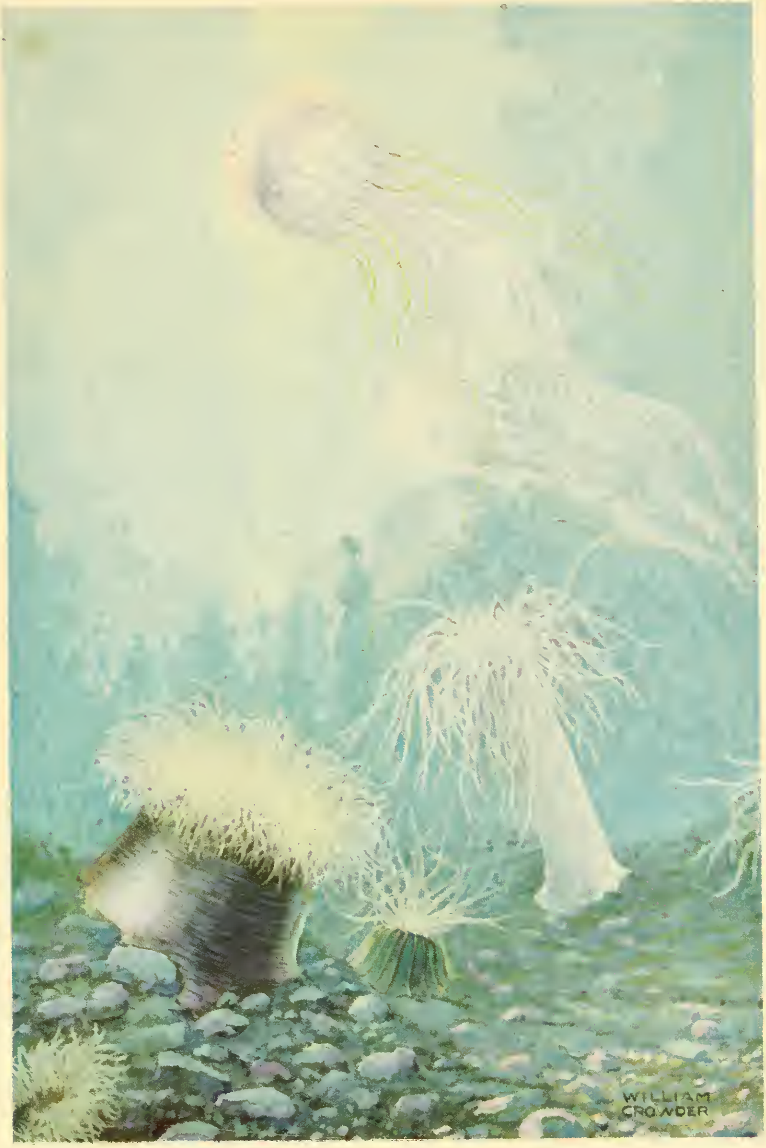
It now remains to consider something concerning the intelligence of spider-crabs as we find this capacity featured in the case of Little Lena.

If, in a previous part of this paper, I have given the impression that the masking reflexes indicated that *none* of the spider-crab's actions is performed by conscious effort, my thesis has been misinterpreted. We do not yet know enough about so intimate a thing as is the human organism to predicate the properties of the brain; no one with certainty, then, can say what are the mental operations of a crab. But that crabs do have some sort of psychism apart from automatic reflexes, which is like that of humans, there can be no doubt. And the degree of intelligence possessed by various individuals differs just as it does among mankind. Indeed, one of the first things to strike the observer of these crustaceans is the decided contrast in behavior between the different members of a tank. Some will seem downright stupid; others, again, will be nimble-witted and betray remarkable superiority over their companions, both in the manner of masking and in whatever requires a conscious effort of a mind. Sometimes in a collection will occur an actual genius, one so far above the others that it would appear to be endowed almost with human-like individuality—certainly with mental qualities more akin to those of higher animals, such as pet birds or puppies, than those we should expect to find in a lowly crab. Such mental qualities our Little Lena proved to possess.

It was not, however, until after she had cast her seventh molt—nearly three months after hatching—that any unusual divergence was manifest in her deportment. Prior to this event she was, in common with her companions, shy, secretive, and apprehensive of human approach. Only by stealth or stratagem could her actions be observed; upon any incautious movement on the part of the watcher she would take alarm, slinking precipitately away into the obscurity of a clump of seaweeds or the remotest corner of the tank. Shortly after the period to which I refer, came a noticeable change. Gradually she began to grow accustomed to my presence, and finally by the time of her next molt

FAIRY AND FLOWER-LIKE FORMS OF THE SEA

Pelagia: a scyphomedusa (upper-middle)
Metridium: the brown-anemone (lower-left)
Sagartia luciæ: the orange-striped anemone (lower-middle)
Sagartia leucolena: the white-anemone (middle-right)


WILLIAM
CROWDER

FAIRY AND FLOWER-LIKE FORMS OF THE SEA

three weeks later, she had become quite indifferent to my maneuvers beyond the transparent barrier of her unnatural home.

With the eighth molting her timidity returned; but it was soon lost and by the time of the ninth shedding she was quite her new self again. And so it was with each succeeding slough until the twelfth and last—it seemed as if after these subtle transformations attending the hardening of the test, the faculty of memory had departed also with the outgrown frame, and the spider-crab, so to speak, was periodically being born anew. Each molting resembled the preceding one in that the behavior of the crustacean was marked in a manner which can be described only as a momentary reversion to its typical traits. But there was this difference: with every changing of its coat, the resumption of acquired habits was more quickly effected; its response to human overtures also became eventually more pronounced and friendly than ever before. The fact is that by the time it reached maturity, the time of its final molting—which in Little Lena's case occurred eight months after the *megalops* stage—it had become so tractable that it learned to take food from my hand as readily as would any common domestic pet. This fact in itself is relatively unimportant until we realize the circumstance that in order to obtain the proffered food, this creature was obliged to leave the bottom and essay a laborious climb to the surface by the way of a lattice-like skeleton of a gorgonia, or sea-fan, which occupied the middle of the tank.

It may be pointed out that even this latter fact fails in significance in view of the probability that this spider-crab, having instincts in common with other creatures, was emboldened by the sheer force of hunger. This, I aver, was not the case. In no sense of the word was it starving. It was never in want of a full measure of food. Yet even were it true that in this instance hunger overcame diffidence, what shall we make of the following? . . .

I have already made a passing reference to the cleaning performance of these animals. The dexterity with which they use their claws in scraping and furbishing their joints and the exposed spaces of their crust, equals that with which they attach to themselves the fragments of their decorative garbs. For many minutes at a time they will go over the margins of their carapace and the surfaces of their legs with scrupulous care—preening themselves with all the fastidiousness of our familiar feathered friends . . . Even at this moment I can see Little Lena at this very employment. I approach her tank. No sooner am I half-way across the room than she detects my approach and straightway makes for the surface by the route she has learned so well during these past eighteen months of almost daily traversing—by the way of the sea-fan rising to the top of the aquarium. Is it because of hunger that she climbs to greet me? I doubt it; she has been well fed but a couple of hours before. At any rate, I will learn. I offer her a tidbit in the form of a flounder's gut, which she immediately rejects as she does all other morsels offered to her in turn, flinging them far from her with a flip of her arm.

We understand each other perfectly. It is not food that Little Lena craves, but the usual mark of affection. So I gently run the nail of my forefinger several times along the rugose ridges of her shell—a familiarity which she endures at first with the same seeming distrustful condescension that a tame bird betrays when it allows its neck to be scratched. None the less, this procedure on my part is to her liking, as is evidenced by the slow opening and closing of the movable finger of the claw corresponding with the side receiving my caress. But her satisfaction soon manifests itself in a most unmistakable way. When I transfer my strokings or titillating touches to a segment of one of her walking legs, this appendage is raised with the very evident attempt to counter-resist the contactual pressure of my hand.

Another circumstance might well be added. Today Little Lena's solicitations of human attention are such that the members of my family can scarcely enter the laboratory without being compelled to pet her. One's first duty on entering the room is to pay one's respects to the crab. At an earlier period there was some novelty in this; but now, I fear, the pleasure first found in this peculiar friendship has partly passed. As a result there are times when these solicitations are not always immediately met; but Little Lena patiently remains near the surface until some one deigns to come—lingering, often for hours, to receive her meed of caressing in compensation for her climb . . .

Now, the point is, can such examples of the spider-crab's behavior be ascribed to instinct or to what we are pleased to term intelligence? If we adopt the accepted definition of instinct as being a hereditary mode of behavior, then the behavior of Little Lena is something else. For here grew up a custom which surely is not only new to the species, it is also outside the experience of the entire race. The truth is that, regardless even of how we construe intelligence, we must give to the spider-crab the credit of possessing this faculty to a very high degree.

VI

This concludes the major results of my researches in connection with *Hyas coarctatus*. But before closing this monograph it may be well, for the sake of the casual reader who may have a special interest in this remarkable creature, to summarize the most pertinent points. Thus:

1. The spider-crab, *Hyas coarctatus*, inhabits the shores and deeper waters of the Atlantic Coast in the neighborhood of New York City and the New England States.

2. The young larvæ hatch from eggs carried about on the abdominal swimmerets of the mother after an incubation period of about two weeks.

The eggs are normally laid during the spring and summer in the year following the mating of the parents. The eggs of a single batch number in the neighborhood of one million.

3. The young when first hatched are called *zoea* larvæ. During the *zoea* stage they increase in size by molting. In this stage the probable number of moltings is five.

4. The second larval stage is known as the *megalops*. From five to six weeks are required to complete the two larval stages. The *megalops* is not known to molt before passing directly into the young crab form.

5. In passing from the *megalops* to the adult-crab stage, molting occurs twelve times. The final molting of the female is accompanied by a change in the form of her abdomen from a triangular outline to a form broad and round. The abdomen of the male remains constant in form. Nor does it appear that he molts after reaching maturity.

6. The life of the spider-crab is three years.

7. Resection of the cerebral mass shows that self-concealment in *Hyas coarctatus* is reflexive, a fundamental part of instinct that can be separated

and studied apart by itself; it has little to do with conscious volition.

8. *Hyas coarctatus* is nevertheless endowed with a high order of intelligence as indicated in the manner of its response to human relations and of its adaptation to abnormal environment.

CHAPTER EIGHT

Hippocampus: A Monograph of the Sea-Horse

I

ONE-TWO! . . . *three-four!* . . . *five-six!* . . . *seven-eight!* . . . Midnight . . .

With this succession of double strokes coming from the bell of the ship's clock on the laboratory wall, closes the period of my personal contact with what is perhaps the most unique creature whose friendship it has been my fortune to cultivate. For at this hour, just six months after the affair already made familiar to the reader, in Chapter Six, the last of the *hippocampids* collected on that occasion expired.

On my work-bench lies its stark form, still wet from the water from which it was just retrieved. As I contemplate its curious lines, the hissing sleet can be heard outside, hurling itself in gusts against the window-panes and the skylight overhead—indicative plainly of a night contrasting singularly with that of the finding of this fish a short half year ago. But despite the wildness of the weather, its effect upon the hour is far from witching, weird, or melancholy. Even the untimely death of the *hippocampid* does not make my contentment less complete.

No other half year has been more revelatory; no like period more fruitful; none more full. And for once, in connection with a major problem, I arrived at a solution without wearing out my eyes or wearying my brain. Let me hasten to acknowledge, however, that whatever completeness may attend so apparently limited a series of observations, was due not so much to the ingenuity of the investigator as to the facile nature of the subject, and the help of a scant literature treating the same. For, notwithstanding the comparative ease with which the *hippocampids* can be studied, little more than nothing regarding them comes to us through the books of science. Even popular writings make meager mention of these odd creatures beyond that pertaining to their unconventional forms. Nor is this silence without a significant reason. The plain truth is that sea-horses, aside from their singular appearance, have not much else to recommend them to the common mind. They appear to lead dull and uneventful lives; and their habits certainly are peculiarly prosaic. Only their development is unusual.

Is there nothing, then, that can be said regarding these odd creatures which is worth hearing? . . . I think that there is much that can be said. It is true that the interest attaching to them is primarily scientific; nevertheless, rightly interpreted, a study of the *hippocampid's* ways holds an attraction which will be found to be fundamentally composed of all the elements of that universally appealing quality known as "human interest."

To such an interpretation I shall address myself, chiefly because I am aware of no popular exposition of the subject, and in order to satisfy what seems to be a prevalent curiosity regarding the ways of a creature as which no other of the sea has so singularly identified itself in popular fancy and of which so little is commonly known. Also, I am no less moved to make this attempt because of the intrinsic attraction which is undoubtedly that of the sea-horse.

But the story of the *hippocampid's* ways, however well translated, would not be complete for the reader without his having some knowledge of its relationships and an understanding of its marvelous structure.

Nearly forty species of sea-horses are known and are described in the systematic works of ichthyology. The individuals of the two different subfamilies vary in size, ranging from two to twelve inches in length in genera such as *Hippocampus*, *Acentronura*, and *Phyllopteryx*, while in the genus *Solenognathus* some attain to a length of two feet. These latter forms, however, do not bear much resemblance to the typical *hippocampids;* they are more like pipe-fishes, and they are found only off the coasts of Australia and China.

The species with which this monograph is concerned is called *Hippocampus hudsonius;* it inhabits the whole Atlantic Seaboard from the Gulf of Mexico to the waters of Long Island Sound. It is this species which is so largely represented by popular pictures, public aquarium exhibits, and conventional decorations and ornaments having a marine motif. Its uniqueness in the popular mind undoubtedly lies in its horse-like head; but to the naturalist it is singular because it is the only fish having a prehensile, or grasping, tail. Long ago ancient observers wondered at its peculiar shape, just as do the majority of the moderns; thus, from their day to this it retains the name *Hippocampus*, from the Greek *hippos*, horse, and *kampe*, meaning caterpillar, or worm—the two derivations referring respectively to its head and tail. Indeed, as one writer has aptly remarked, if a coiled worm were attached to the base of the piece known to chess players as the knight (an object which the head of a sea-horse more nearly resembles than it does the head of even a horse), the common *hippocampid* would be well imitated.

But these are only superficial resemblances. A fish has no neck; what passes for a "neck," is really the abdomen; therefore, there is no true correspondence between the contracted part of the *hippocampid's* body adjoining the head, and the neck of a horse proper.

The head of *Hippocampus*, in front of the eyes, is prolonged into a sort of snout; it is a tube, in fact, bearing at its tip the extremely small mouth and jaws which are numbered among the many strange modifications of this creature's structure. The eyes themselves are prominent, but owing to the circumstance that the iris partakes of the color pattern of the adjacent region of the body, they are inconspicuous in spite of their size. The sea-horse has the curious facility of rotating either of these organs in its socket independently of the other. Just back of the eyes are the large gill-covers. If one of these be lifted, it will be found that the gills, unlike those of ordinary fishes—in which these organs are always arranged in a leaf-like series—are each produced into a clump, a compacted cluster of small rounded nodules, the whole mass having a convex configuration.

The entire body of the sea-horse is encased in a tough horny skin or skeleton. This rigid armor consists of segments allowing but little freedom of movement; the body can be bent forward at the head region and the tail; to a much less degree it can be flexed sidewise; and not at all in a backward direction. As a consequence of this limited range of body movement, the animal is a poor swimmer—it must needs continually cling to some support lest it be carried about against its will by the currents. (Indeed, it can make no headway whatever against a current of the most moderate force.) This it is enabled to do by its remarkable prehensile tail.

When it does attempt to swim, it maintains an upright position in the water, propelling itself with the aid of its single dorsal fin situated on the back about the middle of the body, vibrating this appendage with a rapid undulatory motion. But for the most part, the *hippocampid* remains stationary, shifting about only when such occasions as the demands of love or hunger require. From dangerous enemies, it seldom essays to flee. In threatening circumstances, it relies for protection solely on its inconspicuous appearance. Grotesque and fantastic as it may appear to human eyes, it is in this very bizarrerie that lies its safety from the assaults of natural foes. The numerous filaments and tubercles on its body doubtless do much to help it simulate the weedy growths which it inhabits, but it is further enabled to identify itself with its surroundings by a certain capacity to conform with the prevailing color of those surroundings. Although normally dark—almost black—it can, to some extent, change its hue. Thus, with these natural advantages, together with its habit of remaining for the most part immobile, it easily escapes the casual view.

Yet, despite the fact that the sea-horse is slow-moving, it is largely a predatory animal. Now, most other animals as large which live by preying are active, but this creature, in keeping with its anomalous form, differs likewise from the ordinary in its food habits. Because of the mere size of its mouth, its food material perforce is proportionally minute; this consists mostly of very young shrimps, sand-fleas, copepods, and other small crustaceans —occasionally also the drifting egg of a fish—and it catches these in a curious manner indeed.

Seeing its living morsel at rest on the bottom or on a frond near-by, the sea-horse approaches slowly, peering with head cocked first to one side then to the other in the most ludicrous fashion of a hen eyeing a doubtful caterpillar. Then when within reach it will lie on its side or assume any other convenient attitude and thrust its mouth toward the desired object, whereupon that object will suddenly disappear. There is no perceptible movement of the *hippocampid's* jaws—the resting crustacean has been sucked in so swiftly that its transit escapes detection.

II

So much, then, for the dry details of anatomy and the data of food and physiognomy. Let us return to the dead *hippocampid* which I have before me on my laboratory bench.

Although the sea-horse, as far as its general habits are concerned, is amenable to observation, both in its natural habitat where it occurs and in the indoor aquarium, there is one secret of its life which is exceedingly obscure and which it is likely never completely to reveal. This is the secret of its age. Its longevity is unknown. The outstanding difficulty in the way of determining this fact in the case of any creature that lives at large in the sea, where it cannot be followed, is obvious; but confinement of the *hippocampid* serves no better. For of all sea folk, none is more difficult to make round out its natural span in a restricted environment than is the sea-horse. It does not thrive long in captivity; even in the most carefully controlled tanks, it does not endure longer than a single season.

Still, despite the difficulty presented by the living animal, I am going to hazard a rough guess regarding the *hippocampid's* length of life, although, perforce, I am obliged to make this attempt on little else than the evidence furnished by the structure of the dead creature at hand.

Let it be understood, however, that my attempt is nothing more than it pretends to be—a guess. I vouch for nothing beyond its probability. Indeed, I might add, while on this subject, that the naturalist experiences few greater difficulties than in assembling data as to the natural span of the wild lives he studies. If anything can be more difficult, it is to determine why some animals live longer than others. Rarely does a feral creature die of old age. Disease, adverse weather, lack of food, and enemies all combine to cut short the existence of nearly all individual forms of life. But aside from these factors, there is a natural disparity in the longevity of animals; a disparity so widespread and patent that it is a matter of common observation. Yet, why is it, for example, that the tiger, the lion, or even the hippopotamus, will die of old age long before the elephant will reach its prime? It is said that an elephant will live to be two hundred years old. A tiger is old at twenty years, a lion will live for twenty-five years, and a hippopotamus reaches the age of forty. Then again, a crow or a swan can survive for a hundred years or more while an eider duck or parrot might live twice this long. The fresh-water carp and the pike, and the tortoise, too, have been known to pass the century mark. On the other hand, the lives of insects are sometimes singularly short, although the lives of certain ants are supposed to extend to the length of fifteen years. Queen bees can live for four, and possibly five, years, but the worker bee seldom extends its busy life beyond the seventh week. For these disparities, there is no explanation whatever.

Now the most striking of the structural features of my *hippocampid*, is its coat of mail; a hard tough transparent enamel-like skin covering the entire body. The armor is marked off into distinct plates, or shields, each buttressed and interlocking with a rib-like thickening against its neighbor. The nature of this armor tells me at once that the sea-horse is a *ganoid*, a primitive type of fish, descended almost in a direct line from ancestors which roamed the seas long before fishes with true scales were evolved. The sturgeon, both the fresh- and the salt-water form, is also such a fish.

In the case of the sturgeon and certain of its allies, some fairly trustworthy data are available regarding their longevity. And allowing for probable error or even exaggeration, these creatures and their kind are known certainly to live beyond a hundred years. But fishes in general are notoriously long-lived. Particularly is this true of those kinds which do not travel in schools. It would seem that the more solitary are their habits, the greater is the age to which they attain. Thus the length of life of the salmon, a school fish which dies at an early maturity, contrasts notably with that of the carp, a creature well-known for its independent life and its longevity. Judging from these facts, then, I arrive at the conclusion that the minimum number of years which marks the *hippocampid's* normal span of life must be at least equal to the maximum to which humans attain.

That the sea-horse, therefore, lives to be at least a hundred years, can, from the foregoing analogy, be reckoned as quite probable. And that it probably lives to an age in excess of this period, is indicated in another way. In the latter part of the eighteenth century, Buffon, an eminent, though not always exact, naturalist, undertook a study of the life cycles of various animals as compared with their growth periods with a view of obtaining information which might give more enlightenment on the natural term of life in man. He concluded that the majority of mammals live six or seven times as long as it takes them to reach maturity. Another naturalist, Flourens, later worked over the same ground and asserted that the cessation of growth takes place in the dog at two years of age, in the lion at four, in the horse at five, and in man at twenty. The normal life cycle of the dog being nearly twelve years, and that of the lion and horse twenty-five, it will be seen that these instances represent a period of life the proportion of which is about five times to that of the duration of growth. Accordingly, too, man as a perfectly functioning physical machine should live to be a hundred, notwithstanding the scriptural formula of "three score years and ten." That he has often arrived at an age considerably beyond this, is a matter of common record.

This proportion of five to one is much increased in the case of birds, and vastly so in that of fishes. But assuming that even no difference exists in the relative proportions between fishes and mammals, it may still be maintained on this ground alone that the sea-horse very likely outlives man. Besides, if the actual measured rate of growth of the young captive animal can be relied on, this assumption is still further strengthened; for in the tanks of my laboratory I have found that neither the half-grown individuals which I captured nor the minute young which were born therein had increased in size enough to warrant the belief that they would finish their growth in a decade—and this in spite of the fact that they were well fed and were observed continually to eat. Thus but one inference is left. And a guess that the sea-horse lives to be even more than a hundred years old, is about as good as any other, if not the best of all.

III

This lifeless animal on my bench is a male. It is the selfsame creature which I procured with its pouch laden with young, already mentioned as being among the number taken in the trawl.

As usual in fishes, the male *hippocampid* is smaller than the female. His sex is easily distinguished at sight by the presence of the brood-pouch occupying the forefront of his body in the region between the belly and the tail. This sac-like structure in my male, now emptied of its living load, is flat and compressed against the body, looking somewhat like a leathery shield; but when I first obtained the animal, the pouch was distended and pendent, hanging downward nearly half the length of the tail like an enormous purse. Along the upper middle was a slightly gaping vertical slit, the only opening to the exterior, showing plainly the portal through which the eggs were received from the female and through which the young would issue when the time would come for them to leave.

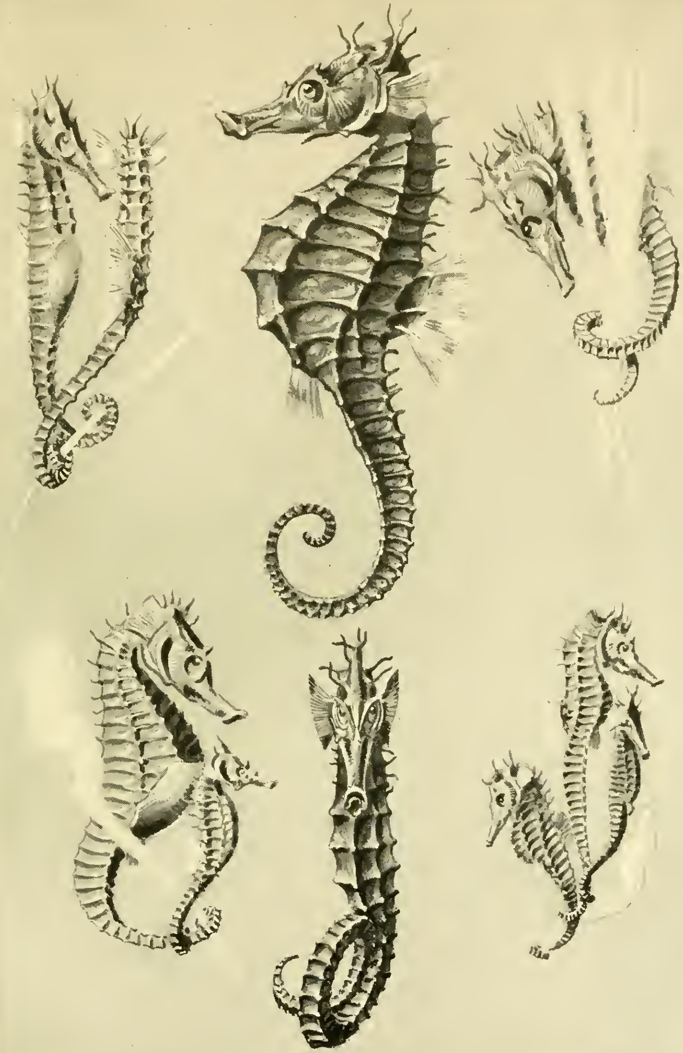
Although the manner in which the eggs are transferred to the pouch of the male was not my privilege to observe, the method of their eventual extrusion after hatching was a spectacle not similarly denied. Indeed, so far as is known, but one observer, Fanzago, seems to have played the part of eavesdropper on these most private pursuits between the female and the male. According to his observation, the male remained passive while the female, burdened with eggs, approached him, pressed her genital aperture to the opening of his pouch, and then retreated. This extraordinary method of copulation was repeated at short intervals; with each contact she implanted within his pouch a single egg. It is doubtlessly during the transference that the egg is fertilized.

The number of eggs thus passed by her to one male probably does not exceed a dozen. But she is an impartial lover, and any likely-looking possessor of a pouch is apt to be impressed into becoming her temporary spouse. It appears that the ovigerous pouch is perfectly adapted to the purpose it serves. Not only is it fitted to receive and incubate the eggs, but also it supplies nourishment and shelter to the new-hatched young. A mucous membrane lines the interior, and this has the faculty of secreting a foam-like substance on which the baby seahorses are supposed to subsist. Prior to this most peculiar kind of impregnation, the pouch walls are thick and well stored with fat; with the presence of the eggs, the organ distends and looks turgid; but by the time the young finally escape from this combined nursery and cradle, it is hanging like a limp and flabby sack.

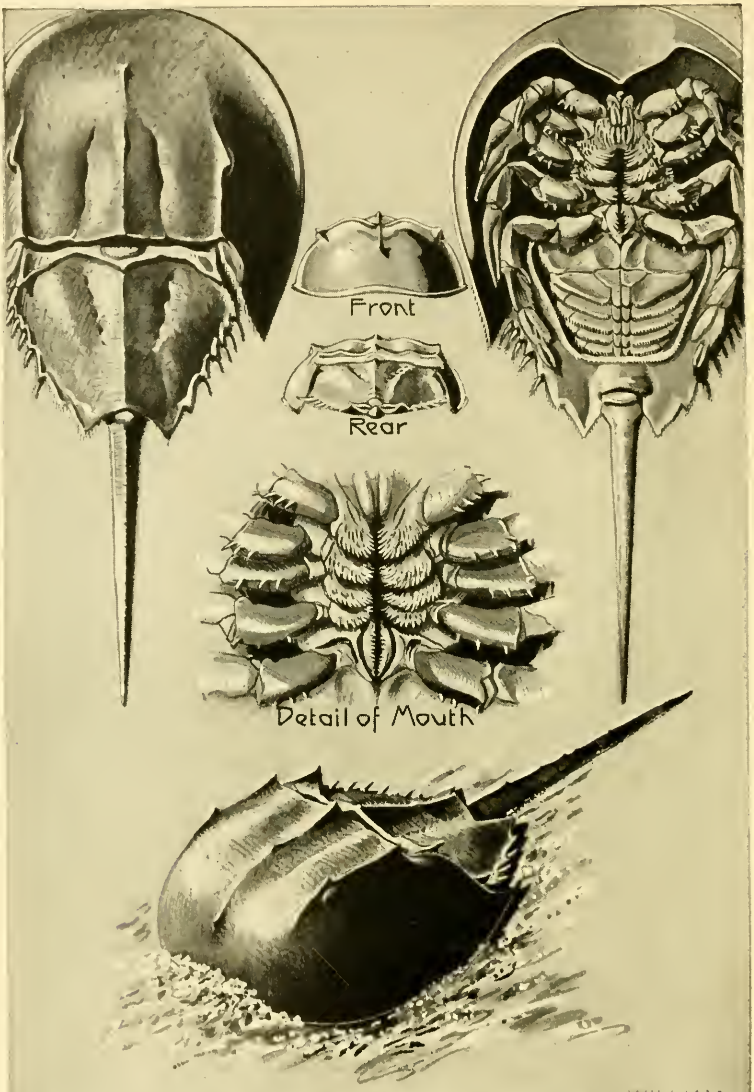
It has been asserted by some that the male forcibly ejects its living burden when the food becomes exhausted from the membrane of the bag. And to effect this release, it is further stated, the parent employs his tail—bending this appendage upward like an inverted crook and literally squeezing out the contents of the pouch. Then, again, it is said that he presses his pouch against some object, such as a shell or stone, to expel the tiny young. It was not maintained, however, that this operation is a parturient process, but is merely a mechanical help in the labor of extruding the progeny.

I am quite certain, nevertheless, that nothing resembling these performances took place during the delivery of the young *hippocampids* that first saw the light in the tanks of my laboratory. So far as the evidence of this particular male is concerned, there was nothing in his behavior to indicate that he was even aware of the necessity of ridding himself of his burden—if, indeed, such necessity may be said to have existed. For the young I saw issuing from his pouch escaped easily and in the haphazard manner of bees coming out of the aperture of a hive—some singly, some in pairs and some in groups—and at no time was there any sensible effort on his side to assist their departure.

As to how many females had chosen him for the depositary of their eggs, prior to his capture in the trawl, cannot, of course, be determined. But the number of connubial contacts must have been comparatively large—possibly more than a score; for fully twenty-five young sea-horses were



THE SEA-HORSE


Front
Rear
Detail of Mouth
WILLIAM CROWDER

THE HORSESHOE-CRAB

counted in the confines of the paternal tank. These were nearly completely developed, and each was about a fourth of an inch long. Although partaking of the general appearance of the parent, they differed from him in their proportions. The head was large, bearing a broad abbreviated snout; the tail was short and rounded. Besides, the armor plates of the new-born babes were soft and somewhat undefined. Yet immediately upon their freedom, they began using their little tails, clinging to such small objects as they chanced to encounter on their independent way. With this freedom, too, the solicitude of the father ceases. Unlike certain of the pipe-fishes (a group closely allied to the sea-horse), which continue to foster their young by readmittance to the paternal pouch after their escape, the duty of the *hippocampid* parent, when once the brood has passed beyond the portals, is at an end.

Difficult as it had been to keep the adult sea-horse long alive, it was next to impossible to rear the young. These began to die off rapidly; some, so it seemed, died "a-bornin'." A few there were, however, that lingered mysteriously on for several months, but these, too, finally went the way of the others, expiring as mysteriously as they had lived. Why it is that this creature, apparently so hardy in its native habitat as to live for years, shortly succumbs in the indoor aquarium is an interesting problem and one well worthy of any investigator's efforts at analysis. It is one of those which is among the hundred other equally fascinating but more or less academic puzzles that I mean to take up, but which I know that my multifarious and more pragmatic employments will always prevent. In the light of the little that is known, any interpretation in this monograph would be out of place.

None the less, some hint as to the possible causes may be gained from certain peculiarities which in each instance invariably preceded the death of my *hippocampids*.

Every amateur knows that certain sea creatures thrive better than do others in confinement. Indeed, there are some forms which seemingly find the tank more suited to their well-being than they do the sea. Anemones, for example, some fishes, and certain crustaceans in the equable temperature of the aquarium and supplied with the proper sufficiency and sort of food, increase in numbers and attain to sizes out of proportion to the common characteristics of their kind. On the other hand, there exist many familiar species, such as the compound ascidians and the zoöphytes, which no amount of care or coddling will continue to keep alive. Yet even some professional workers seem not to be aware that in numerous instances confinement, if it does not kill, sometimes so alters the behavior of an animal that it reflects not at all the history or the habits of its native haunts. Thus we have the astounding statement issued under the ægis of the largest institutional repository of scientific knowledge in this country purporting that the *hippocampids* "converse with one another . . . by sounds proceeding from their mouths." And this conversation, it is maintained, is kept up between individuals "isolated in separate glass receptacles some few yards apart."

Such nonsensical observations so gravely set forth in print are misleading in ways other than the major premise would imply. Aside from the ridiculous assumption that these creatures are possessed of an audible speech, we are led to infer that their hearing is most acute. The truth is, the sea-horse is as deaf as the deadest mummy ever found in a pharaoh's tomb. The sounds—sharp, slight snapping noises produced by the sudden closings of the little lower jaw—which are supposed to represent speech, are not conscious or purposive utterances, but they are secondary effects of a primary but undecipherable cause also manifested in a series of slight trembling movements of the entire body, a quivering which usually makes its appearance at some time just preceding the animal's death. This quivering may occur within a few hours or a few weeks of the time that the sea-horse expires; but, so far as my tanks bear witness, these paroxysms are invariably the prelude to the end.

Notwithstanding that the real mechanism of this pathological condition is yet unknown, there is reason to believe that it is in some way connected with the functioning of the air bladder, the organ which stabilizes the buoyancy of the sea-horse and enables it to maintain its characteristic upright position in the water. The air bladder, comparatively larger in the *hippocampids* than in most other fishes, is distended with gas, the quantity of which is so nicely adjusted that the entire body of the individual is, in short, a very sensitive hydrostatic apparatus. So delicate is this adjustment that if a puncture be made in the air bladder of a big sea-horse, and a bubble of gas even as minute as a match-head be allowed to escape, all equilibrium is lost and the creature sinks to the floor where it must remain helplessly crawling around until the puncture heals and a supply of gas is regenerated sufficient to maintain it once more.

Now it is precisely these symptoms which marked the close of my captives' existence in the tanks. In each instance, contrary to the usual behavior of a dying fish, the sea-horse never floated near the surface; it fell to the bottom before it died. Therefore, in view of these facts, it should appear that the *hippocampids* do not thrive in captivity because of some abnormal condition in their newer habitat to which they cannot adjust themselves. What, then, can this condition be? But one conclusion can be drawn: for, after having eliminated such considerations as insufficiencies of food or of oxygen, and the matter of salinity and temperature, a single factor remains—depth. And this in other terms means nothing more than pressure. Consequently, it is not hard to conceive of the sea-horse as being one of the hungry horde whom competition is gradually driving away from the shore toward the deeps. At any rate, its body is so delicately constituted that it is utterly unable to withstand the strain imposed by prolonged retention in the comparatively pressureless waters of the extreme shallows or under the similar conditions which prevail in the precincts of the artificial tank. The tremors I have told about are doubtless indications of this strain; doubtless, too, the collapse of the creature is caused by the same disorder.

IV

Thus far in this monograph I have set down nothing regarding the habits or history of the subject otherwise than that which relates solely to the physical. These physical characteristics are essentially few and simple, as the reader has doubtless observed—so few and simple in fact that a summary at this point gives us merely the following:

1. The sea-horse, *Hippocampus hudsonius*, is found in the waters of the Atlantic Ocean along the shores of Eastern United States, from Long Island Sound to the Gulf of Mexico.

2. The young hatch from eggs deposited by the female in the ovigerous pouch of the male. Mating occurs in midsummer.

3. The number of eggs received by the male from an individual female probably does not exceed a dozen; but, as the male is known to consort with several females, the total number of eggs contained in his pouch may reach a hundred or more.

4. It is probable that incubation lasts for several weeks, although the exact period is unknown. The young when hatched greatly resemble the adults in general appearance.

5. A month or more ensues before the offspring finally escape from the pouch. In the pouch they are sustained and nourished by a secretion formed by the membranous lining of the interior.

6. Although frequently found in the extremely shallow waters of bays and open shores, the *hippocampid* is inclined to inhabit the deeper areas.

7. Its presence in the very shallow waters is probably due to the promptings of hunger; were it not for its mode and limited powers of progression, which prevent those rapid migrations which are possible to other deep-water fishes, it is unlikely that the sea-horse would ever be found near the shore or at the surface except at night-time.

8. Inability to adjust itself to the conditions continuously prevailing in the absence of pressures

normal to its organism is probably the reason that it soon dies when confined in an indoor aquarium.

9. The natural term of life of the sea-horse is probably a century.

10. The *hippocampids* do not, as has been asserted by some, converse or communicate with one another by means of audible sounds.

But to suppose that this decalogue or the amplified exposition it represents, contains the entire truth about the sea-horse, would be an error. No record of this curious fish can be complete without some reference to those less objective facts which feature it as the most popular ornament of the sea. Nor is it an overstatement to set forth that without a consideration of these subjective facts a conception of the real animal cannot fully be conveyed.

For, after all that may be written regarding the ways of the *hippocampid*, it will continue to maintain its place in the popular mind, not by reason of its life and habits, however inherently interesting these might prove to be, but solely by virtue of its appearance. That it has so wide a popular appeal on artistic rather than scientific grounds, is not a phenomenon. Preëminently it is the most decorative of all the higher denizens of our shores. Other dwellers of the sea there may be which are as odd, others probably more impressively pretty; but truly none is so picturesque.

In a certain sense I am of the same mind as that of the majority. Indeed I confess that I have found fewer allurements in following up and giving literary form to the facts of the sea-horse's life than I have in giving graphic representation of the outlines of its fantastic figure. It has ever been for me most difficult to derive from the study of its life and habits the pleasure that I find in the details of its fascinating form. In short, for me the curves and angles of the sea-horse are not so much material for the pen as they are material for the brush and the photographic plate.

The truth is that a first-hand glance at this creature will tell any one at once why so many others also have preferred to portray its appearance by pictures rather than by words. Nothing in animate nature is at once so somber in its colors and so lively in its lines. Certainly no other living object in the realm of natural science with which

I am acquainted, is so simple in its structure and yet so æsthetically potent purely in the plastic properties of its form.

It has long been held by certain critics that the Grecian urn contains in its outlines all the elements essential to a perfect production in art. It is said to have rhythm (whatever this may mean), harmony, and tone. In fact we are to infer from these violent proponents of classic art, who, by the way, seem unable to express themselves about a form of art which they do not seem to understand, in terms only of another form of art (music) which they probably understand still less, that this "symphony in stone" actually *is* the most beautiful object in the world. Now I am not the one to belittle the loveliness of this overrated jug: its cold, simple beauty cannot be denied; but assuredly it is a beauty which, being cold, can never make me swoon at sight. And if I, like the critics of the classic, could not make my meaning otherwise clear, I should say that it is "frozen music."

There are some, of course, who profess to find in every piece of bric-a-brac labeled by age or patina, a beauty which is the source of everlasting joy; but to such God-given capacity, I can make no claim. For me the thrill of the ancient artifact, compared with that of a natural product, is feeble indeed. After all, such perfect attunements with the infinite are reserved only for neurotics and the genius. If lack of emotional response to conventional creations is indicative, I fall reasonably short of being a neurotic. It is certain that I am no genius. In brief, being but a humble working naturalist-artist, I know nothing of the fine feelings with which the theorists are wont to regard their classic standards of beauty, and understand a little less of the fine phrases by which their frenzies are revealed; I confess, I do not speak the language.

How, then, is it that I presume to speak on so purely abstract and recondite a matter as the Principles of Art? Verily it should seem that I would better be employed with a subject more in keeping with my professed talents, rather than trying to condemn that which I cannot comprehend. My answer is that true art, like true beauty—both of which in a certain sense are one and the same thing—is not artificial, it is natural. Whatever is natural needs no interpretation; it reveals itself alike to all. The poet has truly said that Nature speaks a various language: but in whatever form she speaks it is in a way that none of us fails to understand. Nor are the standards of plastic or of pictorial art restricted to the appreciation of the few; Art in its purest form—and this applies also to music and other modes of expression—has a universal appeal; therefore, the ability for appreciation of the artistic, contrary to the dicta of pundits who can exploit to their own advantage the productions of the painter but who themselves are unable to paint, is not a cultured possession.

The truth is, if we compare the pictures made by the cave dwellers with those of the modernistic school, we will find that such appreciation is not even a phase of culture but a natural endowment. For fundamentally the business of the artist is to interpret an emotional concept. Emotions are several and primitive. And in proportion to the artist's power to feel and to translate faithfully any one of these primal operations of the mind, he may be said to have produced a work of art. Thus, if Massenet makes me melancholy or Gauguin gives me chills, it may be said that they have succeeded as artists; but this is not wholly true. Art in perfection must have the element of beauty.

It is this element expressed by the vibrant and powerful color-combinations of the Impressionists that makes certain of their work, which is otherwise meaningless, throb with life and warmth, and thrill us with a vague charm, while the more accurate, if not more faithful, rendering of the Realist will often leave us cold. After all, the final test of a work of art, like that of literature and music, is time; and although its forms and motivating principles are fundamental and never given to change, standards of beauty will differ among various peoples and stages of society and will alter from age to age.

Therefore it follows that anything, whether produced by man or in Nature, which arouses an emotion, is artistic. It will be seen, then, that a painting, though highly accurate and a perfect representation of a subject, that does not succeed in doing this, may be less artistic than a camera picture which does so succeed. For instance the faithfully painted portrait of the Pleiads is an inferior artistic production to an actual photograph of this awe-inspiring constellation: the first can never convey more than a vague approximation of the emotional appeal of starry space, while the second carries all the thrill of a first-hand telescopic view of those vast and nebulous reaches.

V

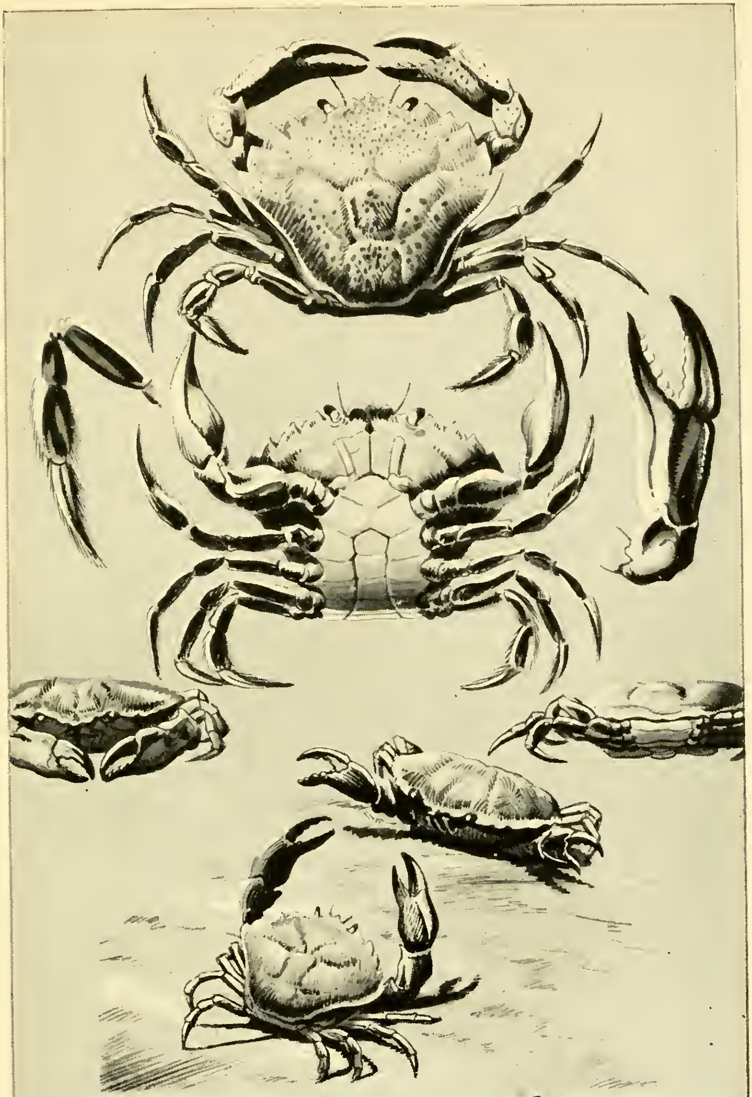
Let us now see how these general conclusions apply to such as the sea-horse. In the creature occupying my attention at the bench, I find, first of all, that which must have struck every observer who has studied the *hippocampids* to any extent, though I can discover no reference to it in the records, and that is the fact that the lines of the sea-horse, no matter what may be the position of its body or what contortions it assumes, are extremely graceful and are suggestive of that one form of beauty which the ancient Greeks defined as being the finest and purest of all forms of linear beauty, that form of beauty which was recognized long before classical standards were set and which has remained unchanged throughout all the later generations of human thought—the form of beauty contained in the gracile curves of a woman's torse.

Not only do grace, symmetry, proportion enhance the appearance of the sea-horse—the virtue of any single one of these qualities being sufficient to distinguish it as an artistic subject—but also in its contours is that added element, *strength*. And it is this which serves to single out the sea-horse among all other creatures of the world which make a bid for our admiration of the pretty and picturesque. That the *hippocampid* pleases the lighter popular fancy is doubtless due in some degree to the attraction of its horse-like head; that it retains a strong hold on the sober imagination of the multitude, however, can be ascribed only as owing to those features which may be said to place it in the very forefront of animate objects of art.

No; let the lovers of lifeless line exalt their urns and other artificialities; for my part I prefer to indulge in such artistic pleasures as are afforded by natural forms, in such as are found in pleasing *Hippocampus*.

I am not unmindful that these personal predilections are vulgar and in keeping with those of the crowd. But a fig for the affectations and farcical refinements of the Chosen Few! What is this "Art" never mentioned by them in print without the *majuscule*, this Art of which they so glibly prate but which they are incompetent to practise? At its very best it is but an imitation. Can the thrill of a beautiful sunrise or the blush of an unfolding flower be revealed by paint or stone with more fidelity than is found first-hand in the original? I deny, too, that the artist is a creator; and on the same grounds. Nature alone can be said truly to create. Indeed, if creative ability in its absolute sense may be taken as the test of an artist, such a one is non-existent. Even the scientist, the synthesizing chemist, the inventor, persons ordinarily considered as coming close under this definition, are not creators; they are, in the last analysis, discoverers. My confession of commonness may no doubt pain the sensibilities of the æsthete, who has appropriated appreciation and enjoyment of the beautiful as properties peculiarly his own. Here, he will hold, is a coarse fellow with a certain flair for beauty but who is incapable of understanding the inner meaning of art; bereft of that temperament, possessed by the true disciple of beauty, and which is essential to attain to the higher knowledge, he betrays by these blasphemies a hopelessly proletariate mind.

Be it so. But it is my belief that no affectation of cultured foibles can give to one more exquisite pleasure in the contemplation of a lily than will


WILLIAM
CROWDER

THE GREEN-CRAB

PREPARING THE NOCTURNAL MEAL

The author's wife declares a welcome intermission during a collecting expedition by moonlight

PHOSPHORESCENT WAKE OF THE "HIPPOCAMPUS" WITH THE TRAILING TOW-NET be gained without these intellectual frills. Is my crude, perhaps, but keen enjoyment of the fragrance floating from a rose bower any less than that of the professional perfumer? I dare say that it is time this nonsense anent the superior refinement in taste of the few for what is truly artistic, should end; that the honest capacity of the many be recognized and given the credence which is its due.

On this account, therefore—my being of the opinion of the multitude in the matter of the sea-horse—*Hippocampus* as a source of study in the field of natural science will probably never overshadow itself in interest as a source of inspiration in the field of art; for me it will ever be an ornament rather than an object, a form for graphic reproduction rather than a subject for research, a model for the brush and pencil rather than a specimen for the lens or knife.

One! . . . Again the laboratory clock recalls the time. Reluctantly I rise and prepare to clear the bench. A swifter and more fruitful half-hour has never passed. And were it not for the reminding bell, my absorption would have continued well into the remainder of the long winter night. Still, the demands of the brain, if not of the heart, require that I spend a portion of my time in bed; but before turning in to sleep, I begin to arrange things for the morrow. In putting away my pretty plaything (for certainly I have ceased to regard it as related in any way to work), I take a last look at its pleasing profile; then my eye roves round the room and catches sight of something on the opposite side. It is my weathered camera case; on the frayed and time-worn canvas covering is the faded counterpart of the sea-horse, my personal device, long since adopted and stenciled on this and other various pieces of the paraphernalia of my trade, adopted in truth before I had come actually to give special attention to animals which are strictly marine . . .

Yes, I am more than ever convinced that I have reached the right conclusion in my contemplative pastime; verily *Hippocampus* stands alone—not without reason have the delightful and decorative lines of its form become familiar to the least of mankind as emblematic of its habitat, become by common favor the accepted and universal symbol of the sea . . .

CHAPTER NINE

Loligo: A Monograph of the Squid

I

AN aspirant to the trade of letters once asked a noted writer what course should be pursued by the apprentice in order best to attain to perfection and success. The master's answer was: "The first thing you should do is to take Literature and wring its neck!"

I have always considered this cryptic injunction to be nothing if not original, by Flaubert to his disciple de Maupassant, as one of the finest phrases coming from the French. Now, although it is not my aim to arrive at immortality in following any such advice, I am moved to establish a precedent, nevertheless, in the expectation that my form of presentation will confer upon the reader a clearer understanding of the creature which forms the subject of this monograph. For what I purpose to do is precisely this: I am going to depart from the customary rules and fly into the face of tradition by wringing natural science literature by the neck; I am going to begin this paper by giving at once a summary of its observations and conclusions, instead of putting this summary in its accepted place at the close. Moreover, I purpose throughout this paper to treat its subject, not in the usual language of natural science literature, but as a narrative, in terms intelligible as my limited powers permit, yet at least with an honest effort not to appear profound by being obscure.

Although at the very considerable risk of anticipating myself, I conceive this departure from the established form of procedure to be justified in that it will enable the reader to follow with added interest those developments in this theme which lead to the full and final revelation of the foreshadowed facts. And this, too, can be accomplished without depriving the reader of his rightful privilege of indulging for himself in those speculations which are not the least of the amenities found in the dénouement of an unfolding plot. But aside from even these considerations, I hold that the life of the animal we are about to treat is so inherently engrossing that no account of the historian need rely on climacteric props to uphold or enhance its strange interest.

The facts we will find are as follows:

1. The squid, *Loligo pealei*, var. *pallida*, occurs in the waters of the Atlantic Ocean, and ranges from Cape Cod to the Carolinas; but it is most numerous in Long Island Sound.

2. It attains to about a foot in length, the male being slightly smaller and more slender than the female. Full growth is completed in about a year after the hatching of the egg.

3. The eggs are laid by attaching them in capsulated clusters to seaweeds, rocks, shells, and other solid objects. They are laid from spring to midsummer. Within a few weeks the young, a little more than an eighth of an inch long and of the same general appearance as that of the adult, make their escape. By the end of autumn they are two inches in length; the following summer they are full-grown.

4. Mating occurs from spring to early summer. Fertilization of the eggs is effected by the male's implanting a packet of spermatophores within the mantle cavity of the female where the sperms are liberated at the time of the extrusion of the eggs.

Implantation of the spermatophores is accomplished by means of the "hectocotylized" arm of the male, which is the left undermost arm and which is so modified as to perform the functions of reproduction.

5. The number of eggs contained in the anchored capsules of a single laying is about ten thousand.

6. The range and the rapidity of color changes possessed by the squid are greater than those possessed by any other creature in the sea. It is shown that its chameleon-like capacity is not primarily concerned with concealment, but is, in some way not understood, related with the seasonal mating activities of both sexes. For the real purpose of rendering itself invisible to its enemies, the squid relies on its ink bag.

7. There is strong reason to believe that although the outstanding function of the ink bag is to produce a masking cloud, or "smoke screen" for the confusion of its foes, it has the secondary property of functioning as a scent-producing gland—thus enabling this gregarious creature better to follow the trail or trace the whereabouts of its swiftly traveling fellows.

8. The term of *Loligo's* life is unknown, but it is probably not more than five years.

9. General habits and methods of feeding, swimming, etc., are described and discussed.

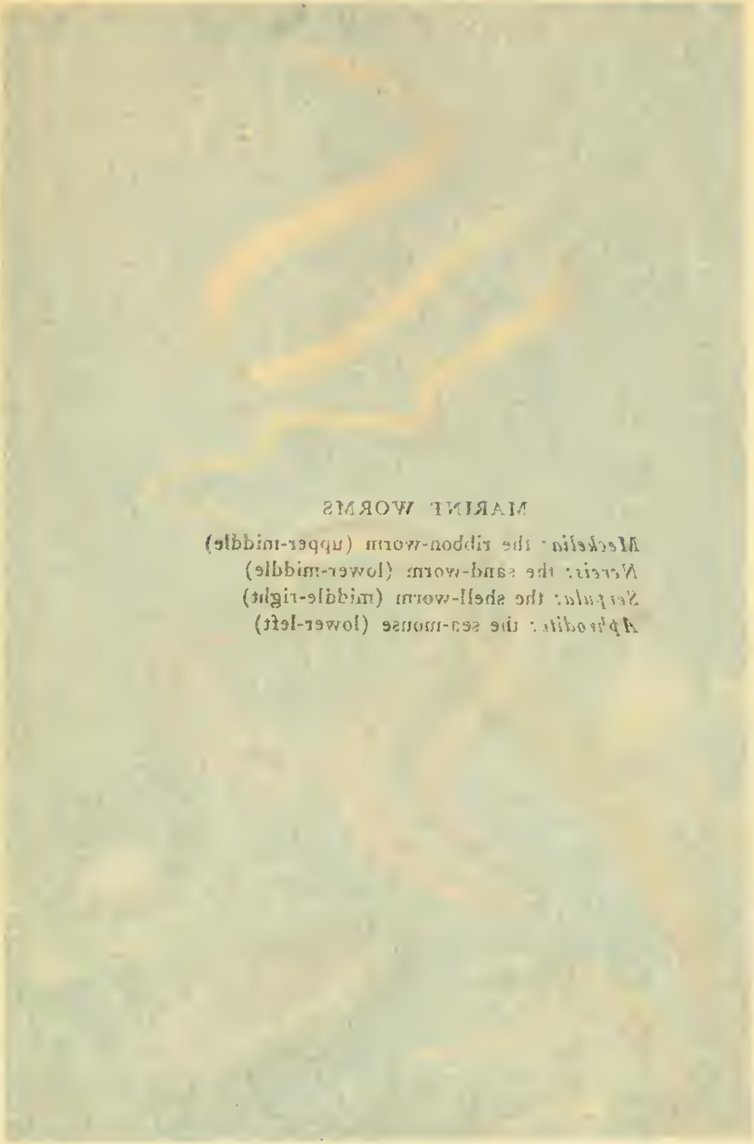
II

Contrary to the customary experience of others, my own initial contact with *Loligo* came about not in the open sea or the wide watery reach of the Sound or in any other expansive arm of the neighboring Atlantic. The acquaintance began at my very door, so to speak, within the restricted confines of one of those innumerable watercourses which during the recession of every tide thread the salt marshlands immediately adjacent to the premises of my laboratory-studio home.

At the time whereof I write, I had, it is true, what may be called a not inconsiderable book-acquaintance with the squid, as well as with the greater majority of forms which commonly frequent the local shores; but my actual meetings had been few. I was, in a way of speaking, a new-comer to the neighborhood of the sea: it had been but a short time before this period that a long-looked-for leisure and opportunity came, wherein it was at last possible to give active heed to the overtures of its lowly inhabitants. It was, to be frank, with a view to the cultivation of a closer acquaintance that I acquired the place which is in a most peculiar sense at once my workshop and my haven of rest.

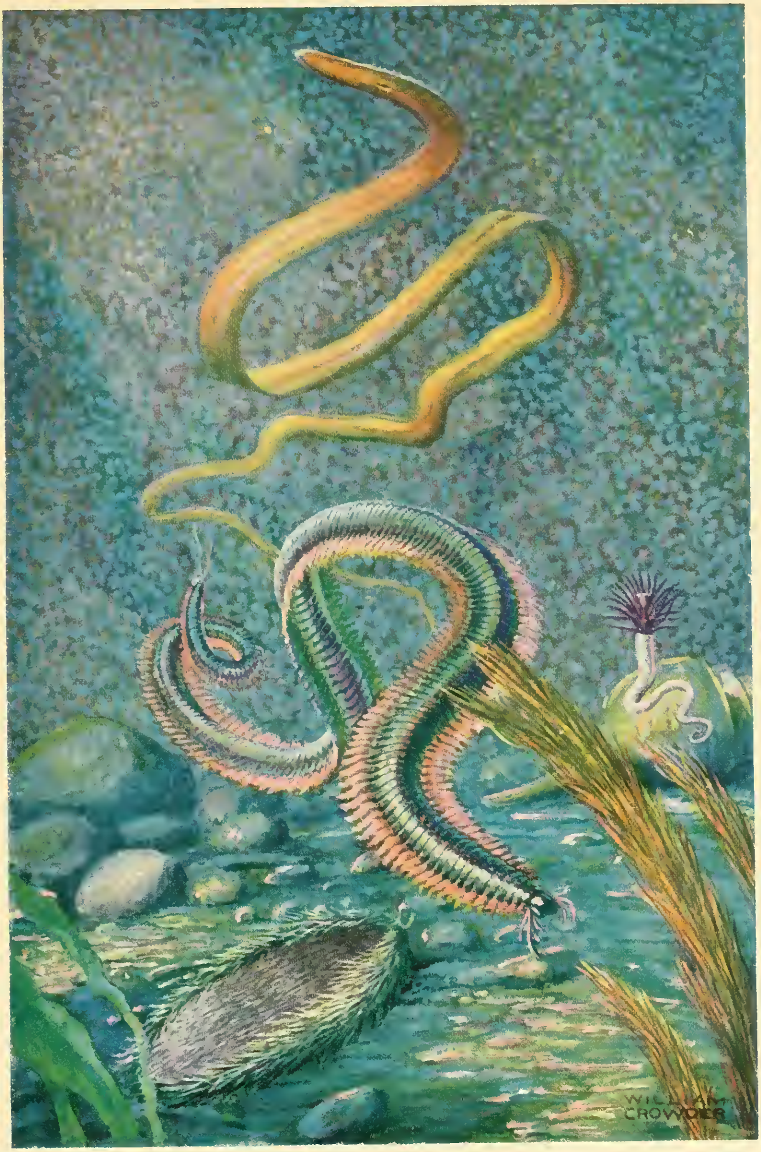
And what strange and manifold friendships has not this humble sanctuary seen me form! Little did I surmise when first I selected this retreat the wealth of memorable meetings the ancient dwelling and its prehistoric precincts eventually would have in store. I use the adjective "prehistoric" in relation to the present, without special reference to the past: for it is not easy to conceive the marshland as other than a present-day primitive world. Except for its constantly changing contours, such as is its general character to-day, so it was in ages past, and so it seems likely to remain, undisturbed by man, for ages hence. Indeed, the fossil vegetation buried in the bosom of the surrounding hills is not of an older order than that which thrives luxuriantly on the hummocks of the marsh.

This salt marsh, reaching in shortest dimension, from my house to the hills across the cove, on the north, and, in longest dimension, extending to the



MARINE WORMS

Meckelia: the ribbon-worm (upper-middle)
Nereis: the sand-worm (lower-middle)
Serpula: the shell-worm (middle-right)
Aphrodite: the sea-mouse (lower-left)


WILLIAM
CROWDER

MARINE WORMS

harbor, on the west, covers an area of more than fifty acres. The sole vegetation of its many hundred hummocks is composed of thatch (*Spartina*), a high reedy grass which in full growth is rank and luxurious and rises well above the height of a man. On early spring days, when the tide is out (twice daily this entire tract is inundated by the waters of the sea), its rolling meadows of glistening green spread before the eye like a sea of frozen swells—if I may use an extravagant simile for what is surely an extravagant sight—as under the vernal sun and the invisible caresses of a freshening breeze, its immobile billows sparkle with the play of innumerable, intergrading, emerald lights.

But not always does it present so pleasing an aspect. It is a marsh of many moods. Sometimes it manifests itself in a way which scarcely allows a parallel. Particularly of certain autumn evenings here, when the heavens are heavy with grayness, and the low-hanging sky is breaking into one wild route of storm-clouds—like phantoms fleeing from some nether-fiend—it takes on a troubled look; you may see stealing over the landscape a shuddering, as from a ghostly touch, a vast trembling; and you may hear a sibilant murmuring, like a spirit whisper, as the slithering blades bend before the gale. Then it is that you will observe the most abject of its moods; during the force of the blast, the expanse flattens itself as if in fear, it loses its cast of green and turns to gray; and with the passing of the squall its countenance reflects the corpse-like color of the clearing sky . . . a color which is heightened to the glow of glaucus-gold when finally the setting sun breaks through the storm-rack and catches the leveled reeds in its slanting rays . . .

Much of the marsh soil—in fact, most of it—is mud. None the less, the charm of a single summer morning spent at low tide among its many arcaded creeks and tiny winding waterways is inexpressible, something never to be forgotten. Few places so close to the haunts of man offer a retreat as secluded, as seemingly remote. It is a world peopled with beings as utterly removed from the ordinary ken as might be those that are popularly, but mistakenly, conceived to exist on the planet Mars.

Part of this strange population is indigenous; that is to say, the millions of mussels attached to the exposed roots of the reedy growth surmounting the overhanging banks, and the vastly more numerous assemblages of smaller mollusks, such as *Nassa*, the mud snail, and *Littorina*, the periwinkle, are inevitably in evidence.

Perennially present, also, but seen only when the hummocks are free from frost and ice, is the multitudinous fiddler crab, *Uca pugilator*, pugnacious in appearance, but not in fact. The holes of these innumerable fiddlers perforate the surface of the spongy dripping soil, and lead to the labyrinthine burrows which honeycomb the marsh—countless tunnelled chambers which contribute greatly to the softness of the porous and saturated earth. If the stranger, who finds himself straying into the stillness of this retreat, stands motionless for a while, he is likely to be deceived by a barely audible sustained rustling which he will at first mistake for wind as it passes over the reeds: he will soon note, however, if he is in the least observant, that the source of this sound is as strange as is its unceasing tenor: it is the perpetual crawling of the crabs as they move about over the soggy soil. Stealthily and cautiously they crawl, suspicion marking the most minor movement, as they go about sidewise carefully searching the ground for the microscopic algal food which they scrape up with their fore-claws and consume on the spot. Each male is easily distinguished by his great pincer—an appendage so proportionately big that it is practically useless; and this he carries folded before his broad body in a manner that readily suggests its popular name: yet it resembles not a fiddle so much as it does a huge bass viol. But let there be the merest gesture, such as the raising of an arm or a turning of the head, and immediately there will be a swift hurrying and stampeding on all sides; in another moment the fiddlers will have scuttled pell-mell, each into the nearest of the hundred surrounding holes; and silence absolute will reign once more, broken only by the occasional splash of a falling drop from the moisture-laden banks, or the startled croak of some unseen marsh-hen just become aware of a human presence—a water-fowl which makes its living off the inhabitants of the pools and sedges bordering the sea.

Yet by far the larger population is transient, if I may so express it; it is not peculiar to the marsh alone; its components for the most part are forms not infrequently found to be the regular tenants of the rocks and weeds and wharf-piles, in the quiet waters of tide pools or along a sheltered shore. But the shallow streamlets here hold hundreds of these forms, both free and fixed, which during the egg or larval stage have drifted in with the tides and remained to complete their growth, never wanting in these prolific precincts the means of livelihood no matter how prolonged their stay. To list these various vagabonds, would be to give almost the entire catalogue of the common creatures of this section of the Atlantic Coast. However, conspicuous among these are such fishes as the ray, the crab-eater, the killifish, and flounder; crustaceans, such as *Gammarus*, the scud, and *Orchestia*, the beach flea—to say nothing of the prawn, *Palæmonetes*, or *Crangon*, the shrimp—prevail by the millions, while the larger forms like the green crab, the mud crab, and the hermit crab can be reckoned by the score; of the different worms and mollusks deserving mention, the numbers are too great even to name. And then there are the numerous anomalies, which to the uninitiated can be recognized neither for plants nor animals, the strange, yet familiar, encrusting animal growths and sponges, the soft-bodied polyps, the sea-squirts and their colonial cousins, the compound ascidians—living rosettes of purple which give little outward evidence of their affinity with higher organizations having a backbone.

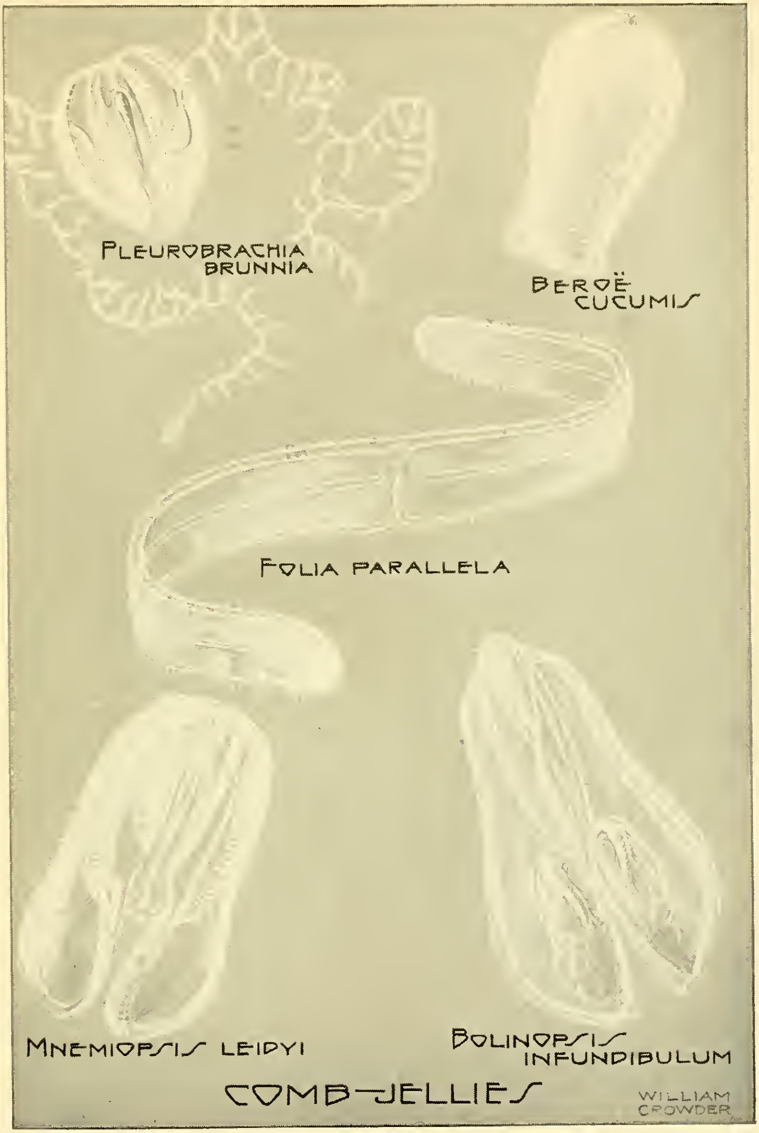
Many are here, however, of a far more temporary kind. These are those travelers who, straying in from the sea during the height of the tide, have tarried too long and were left to linger momentarily in the deepest of the ditches. And it is among these stragglers that are to be found those forms and fantasies which betoken beings of another, but strange and beautiful, world. Floating colonial hydroids, amazing bright blue or pink transparent campanulate animal-forms attached along a common stem at the top of which is a fairy-like float of clustered flowers, tenuous as dream-stuff, swing rhythmically along through the water, swaying with graceful motion. Bewitching, too, are the medusæ, or little jellyfish forms of hydroids: drifting translucent disks of azure with veins of violet, pulsating like spectral hearts—or maybe rose-colored bells bearing around the rim a row of tentacles, impalpable, yet visible as in combing the surrounding water in search of food their treacherous undulations reflect the soft luster of crimson satin strands.

III

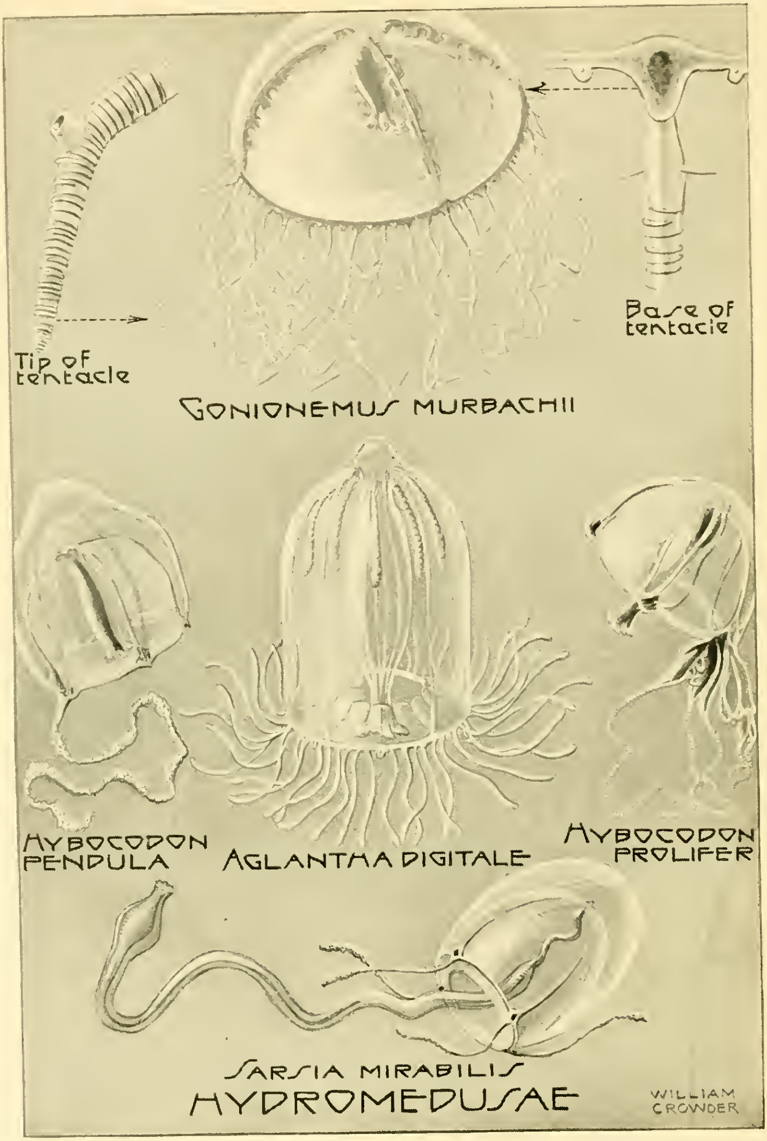
A May morning well advanced had seen me since the breaking of a magnificent dawn making my way here and there among the wider waterways of the marsh. I was exploring for the most part in those channels, the graveled or mussel-bedded bottoms of which were sufficiently firm and sustaining to enable me to wade without sinking over the top of my hip-boots. The weather without was clear, cool, quiet; but, despite the prevailing temperature, between the banks of the breathless bayous, the sun beat down with a blistering light. My progress was slow. So slow was it that it seemed to excite the sinister curiosity of a gull which appeared at repeated intervals and flew around me in narrowing circles, meanwhile uttering its peculiar squeaking cries. For many minutes at a time, when coming upon some sight singular to my eyes, such as the fearless familiarity which the killifishes displayed toward my person, or the opposed and belligerent behavior of the sticklebacks toward other minnows which came too close to their retreat, I would remain motionless, not deigning to interrupt by so much as a movement of a finger what I then considered as a spectacle such as only the best of fortunes would repeat. Nor was I less inclined to forgo that higher intellectual pleasure which such a sight is certain to produce.

Invariably upon such attempts as I did make to proceed, some exhilarating contact of my foot with a flounder or the more exciting touch of a startled eel, contrived further to arrest the casual tenor of my course. The novelty of these numerous sights and encounters, however, was as nothing to that of the singular meeting which I am now about to describe and which was the climax of that series of wonders which occurred that marvelous morning.

And yet this meeting occurred in the most commonplace manner—I was standing in the midst of a mussel-bed which rose reef-like out of the shallow depths, engrossed in the erratic course of a swimming scallop that in some way had been carried from the harbor by the preceding tide. The rapid opening and closing of its bivalve shell had brought it close to the edge of my tiny island, to which point it was followed by a company of curious minnows attracted doubtless by its appearance of floundering, fluttering helplessness, which indi-


Pleurobrachia brunnia
Beroë cucumis
Folia parallela
Mnemiopsis leidyi
Bolinopsis infundibulum
William Crowder

COMB-JELLIES


Tip of tentacle
Base of tentacle
GONIONEMUS MURBACHII
HYBOCODON PENDULA
AGLANTHA DIGITALE
HYBOCODON PROLIFER
SARSIA MIRABILIS
WILLIAM CROWDER

HYDROMEDUSAE

cated the possibility of a forthcoming feast. Then it was that my eyes focused upon an object, an apparition, faintly outlined on the floor beneath. I recognized it almost at once for what it was—a squid.

As I have previously apprised the reader, this creature—here actually met with by me for the first time—was not by any means unfamiliar. ample reading, and seeing its plentifully-pictured image, had prepared me to identify it at a glance. But no reading, no picturization were quite possible to prepare me for the shock actually of seeing for the first time, unexpectedly and in the circumstance related, so unconventional and weird a countenance. That frightful stony stare alone, was enough to cause a shudder; but the wicked-looking sucker-arms perpetually poised in readiness to pounce upon prey, and the fiendish proportions of the body—an animated death-dealing arrow—terminated by a broad batwise-spreading fin, all combined to mark it as the Devil's very own.

Moreover, its aspect was not without a suggestion of the gruesome. It came closer, languidly, tail foremost; and as it did so its body, cadaverously pale, became more strongly contrasted against the blackness of the mussels covering the bottom. Meanwhile, I made not the slightest move, standing as one transfixed, lest any action on my part would startle it away. I divined immediately from its size—it was less than six inches in length—that it was not yet full-grown. In the clearness of the water every feature was visible, and I could almost count the sucker-cups which were aligned in a double row along the inner side of its triangular, tapering arms.

It was by observing the details of these latter appendages that I first began to note some peculiarities which even my inexperience did not prevent me from interpreting that all was not normal with this squid. *Loligo* is a decapod; it is supposed to have ten arms; my meandering specimen had but eight. Moreover, its hide in places was hanging in shreds—an exfoliation which I knew was not natural to any creature of its kind. But the most significant aberration that struck my naturalistic sense, was that which appeared in the behavior both of the squid and of the minnows near-by which were its natural prey. Neither did the squid take notice of the fishes, nor did the fishes appear to be disturbed by the presence of their enemy, the squid. Now such things were contrary to reason, if not to what I had read . . . It presently became only too plain that this creature had in some way been injured and was sick unto death.

At this point I resolved upon its capture. Aside from the feeble effort with which it had approached the spot where I was standing, it made no further attempt to swim, remaining resting on the mussels without betraying any other sign of life than a scarcely perceptible expansion and contraction of the sides of its body—a rhythmic suctioning and discharging of water by the mantle—the way in which it breathes. To accomplish my purpose, it was necessary that I cut off the retreat of the animal by taking a circuitous route and coming upon it from the opposite direction; for I was without a net or other means of taking it, and was, therefore, obliged to capture it, if possible, solely with my hands.

In the instance of this particular creature, this was a project far more facilely accomplished than I anticipated. But what I learned from later experience with *Loligo*, it is only by the utmost stealth that the stalker can hope to apprehend this wary beast. Had this sickly squid been in its full faculties, even my carefully executed approach could not have contrived to corner it. The nearer I drew, the more obvious it became that my caution was needless; the squid by this time was half-turned on its side; drawn by the current in the deeper channel, it was drifting slowly away from the mussels, its posture and its appearance bearing the unmistakable stamp of death. As it was, I had merely to seize it around the body and lift it out.

Yet vitality was not entirely extinct; for as soon as the squid was in the air, I heard a soft convulsive soughing and felt a few contractions of the mantle as it made its final gasps, so to speak, for a sustaining breath of life. Whereupon I replaced it in the water. It sank at once to the bottom—now irretrievably dead—an ascending column of multitudinous silvery bubbles coming from the rapidly-filling mantle-cavity, bursting at the sunlit surface like the tiny explosions of an effervescing wine.

The brief inspection I was able to make while it was in my hands, revealed that its two longer tentacular arms were missing; they had been torn or broken off at the base. With the loss of these primary grasping organs, the creature was rendered practically powerless to apprehend its prey, with the consequence that soon or late starvation must ensue. That weakness from this cause led to its demise, I have every reason to suspect; but as to how it came by the loss of its appendages, I cannot even guess. It might be added, however, that this form of mutilation is more curious than this particular instance would seem to indicate: for since that eventful date, not a year has passed which has not brought to my nets or to my notice in other ways some of these individuals maimed in the same mysterious way. Beside the evidence of its skin, slight lacerations on its body indicated that it had been attacked. It is probable that, from the circumstance that the normal animal is one of the swiftest and ablest swimmers in the sea, these latter injuries had been inflicted while it was in a defenceless and moribund condition.

For a moment I studied the dead creature, noting the faint purplish freckling of its chromatophores (as the pigment cells underlying the skin are called) which spread over its back and to a lesser extent around its sides, leaving the body livid underneath. Then unslinging my camera, I steadied myself, and snapped its picture. But during this operation, I did not fail to observe out of the corner of my eye that something unusual was taking place in the water about me. Almost immediately following the flick of the curtain shutter, a shadowy form streaked past my side. So ghostly indistinct was it that at first I was misled; I mistook it for a ripple-shadow passing over the floor. Then this was followed by another—then another —then several others . . . And I realized now with amazement that I was in the midst of a small school of this selfsame creature's fellows, adult living *Loligos*, darting here and there in the manner made familiar to me in the descriptions of the squid.

My own immobility had served to make me inconspicuous; the roving animals doubtless taking me for part of the inanimate surroundings and, therefore, an object not to be feared. Occasionally one of the spectral figures would approach almost within my reach; tail foremost it swam, without the assistance of any appendage, without a single perceivable movement of a muscle. Then with surprising suddenness, it would stop short, and with the same seeming effortlessness reverse the direction of its course but not of its body: this latter method of locomotion, however, with head and arms to the fore, was less frequently observed.

A school of killifishes to the number of perhaps a score, now came upon the scene, the individuals working their way in characteristic fashion along the water's edge, stopping repeatedly to nibble at some indistinguishable morsels which they seemed eternally to find among the mussel shells. Unsuspectingly they drew near until well within striking range of the squids. Then a sudden panic seized the small fishes, showing that they had at last caught sight of their powerful enemies. They dispersed in all directions, some in their effort to escape hurling themselves clear out of the water, others diving straight into the bottom, burying themselves completely among the mussels or some patch of gravel or of sand. A few, however, were not so alert; and these paid the penalty of slow-wittedness with their lives. The squids were among them with phantom-like swiftness, their torpedo-shaped bodies shooting through the water with a speed far surpassing that of their prey. The slaughter was awful. The unfortunate fishes were each seized by the long unerring pair of tentacular arms of a squid and brought up to the sharp parrot-like beak and dispatched with a bite through the back.

At this conjuncture, one of the larger *Loligos*—a full-grown female—sighted the small dead individual at my feet. There was no mistaking the intent in the look of her horrid eyes. Nor was the capacity if not the nature of her emotions less plainly indicated. As she swam up to the lifeless squid, her body, colorless and clearly contrasted against the dark areas of the bottom, now became suffused with a succession of deep purple flushes. That these changes of hue were not for the purpose of concealment was indicated by the fact that the creature made no attempt to maintain its color in harmony with the prevailing tone of the floor; its violet blushes were produced without regard to the character of the bottom, and at times it was rendered even more conspicuous when hovering over a patch of dead bleached and white shells. None the less, these alternations were startling to behold: the weird aspect the squid presented in changing from shadow to substance, or from a being of ponderable form to a veritable ghost, impalpable in appearance, could be well conceived to cause consternation if not to strike terror in its living prey. This creature had just finished consuming a part of a fish, discarding a goodly remainder, to attend to the little squid. It was evident that an attack was imminent. Did it know that the animal was dead? Did it intend to devour it? . . .

My contemplations were cut short. The larger squid bore down upon the carcass, and with a half-turn grasped it with its sucker-arms and brought it to its mouth and swam away . . . Its gluttonous instinct had made it a cannibal as well as a ghoul . . .

IV

In these circumstances began my acquaintance with *Loligo*, the cephalopod which, barring perhaps its brother, the octopus, is by popular consent accorded the invidious distinction of being the most unprepossessing creature belonging to the sea. My own impressions upon first meeting with the squid were those of repulsion by its appearance and horror at its conduct. I have already touched upon the cold stony stare, the wicked-looking sucker-arms and the weapon-shaped body with its terror-striking tail, but I doubt whether these physical features considered by themselves are adequate to account for the feeling of dread which *Loligo* inspires. There is in this creature, as in no other living thing, the aspect of a machine of weird efficiency: and the singular parts serve only to emphasize this aspect.

And yet this much maligned mollusk is not without a beauty of sorts. Will it surprise the reader to learn that despite first outward appearances to the contrary *Loligo* is tractable, that beneath a fearsome exterior is a really engaging personality, that its general habits and life history have a most peculiar charm?

So at least was my discovery when later my ill-inspired interest inevitably led me to further our acquaintance in its natural haunts along the Sound. Who of us, in our everyday superficial contacts, have not at some time met with persons whom at first sight we regarded with instinctive dislike, only to find later, when some chance or circumstance brings about a better understanding, that our antipathy resolves into sentiments of love? I am here referring, of course, not to those serene and saintly souls with an itch for impossible perfection, but normal human beings.

Well, so resulted my long relations with *Loligo*. Its personality, like that of humans, needed only to be understood to be appreciated. To-day I look upon it in quite another light. Even its outward appearance has lost the sinister and ghastly aspect which first I found to be the most effective of its several forbidding features. No longer am I subconsciously constrained to compare its coral whiteness with the color of a corpse: in the place of a once-seeming pallor of death now prevails an opaline hue, softly iridescent, alluring, of ghostly, gleaming nacre . . . In brief, a growing familiarity has led me to regard it with feelings of genuine good-will.

With its mystery removed, almost any creature is bound to appear in a more friendly and favorable light. As it is in this light that I should like to have *Loligo* remain in the mind of the reader, I shall proceed at this point briefly to consider certain of its physical features; a proceeding which will dissipate much of its strangeness at the start. But for the sake of conciseness, my method of doing so much necessarily oblige me to appear dogmatic; to attempt to prove all the whys and wherefores in this place would be to stretch this paper to an inordinate length. Any reader who has the mind to do so, may find ample substantiation in a numerous literature or by a first-hand study of the animal itself.

So, to begin, whether it appears credible or not, whether it is agreeable or not, whether it seems ridiculous or not, accept my word for it that it is nevertheless a fact that the squid is affiliated on the one side with that most wondrously beautiful creature, the pearly, or chambered nautilus, and on the other side with the common oyster and the clam.

The shell in *Loligo* is degenerate, having been reduced to a mere lengthened scale imbedded within the mantle. This internal shell, lying lengthwise in the place and the position one would in higher animals expect to find a backbone, no longer retains even its calcareous character but is represented by a chitinous structure, or gladius, called in reference to its peculiar shape, the "pen." The squid is a mollusk that has outgrown its house; the mantle and other conspicuous fleshy parts, instead of being enclosed in a shell, reverse the order and themselves enclose the shell. Throughout the cephalopods, this shell shows various stages of degeneration; completely disappearing in the octopus, a close relation of the squid.

Properly speaking, the squid swims neither "backward" nor "forward." The so-called tail fin is not at the posterior end of the body, but is at the highest point of what is actually the back. And strange as it may seem, the sucker-bearing "arms" of this paradoxical creature are in reality its foot. How the sucker-arms were derived from the forepart, and the siphon from the middle part of the foot, while the cone-like body had become elongated in a dorsal direction—in truth, the way in which all its evolutionary changes have been brought about would make an interesting tale in itself, had we the time to take it up.

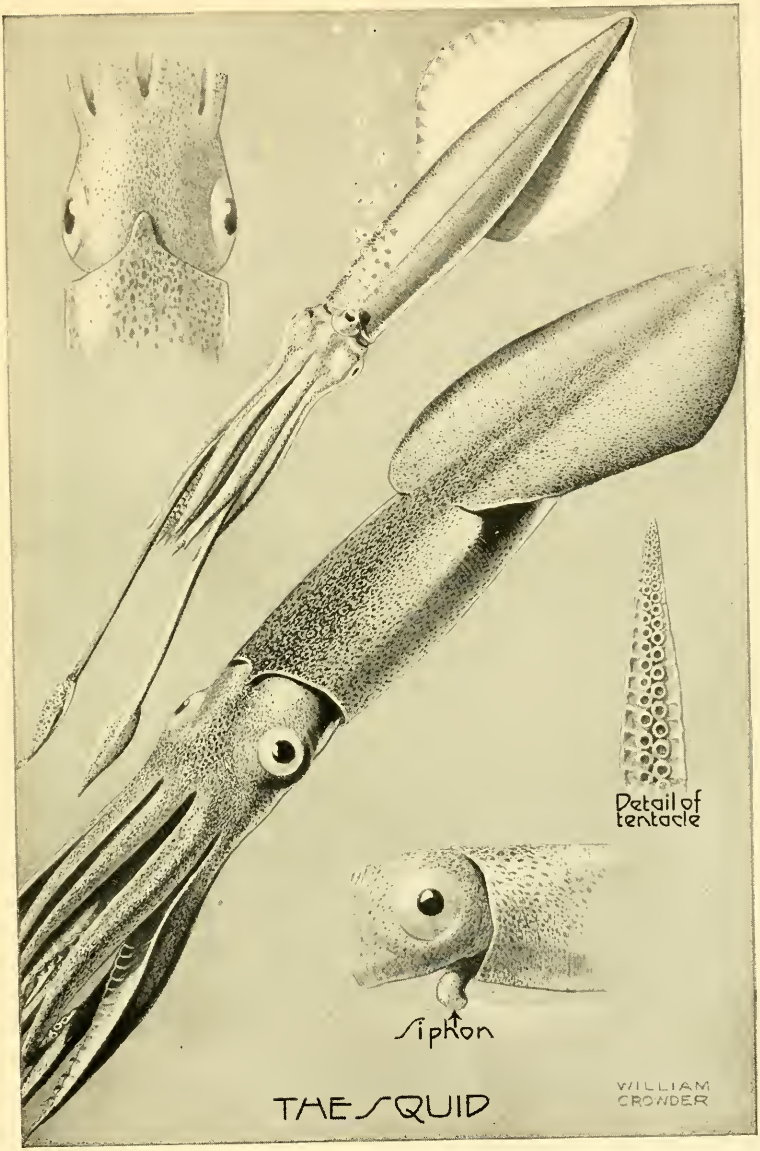
My employment of the term "hectocotylized arm" in the opening section of this monograph must have puzzled the lay reader—even as I was puzzled when first I came upon it in the literature of the cephalopods. Perhaps, also, the reader—as I, too—looked up its meaning in modern dictionaries or reference works, and with the same result;

which is to say, a worse confusion of what was already a vague idea. The word "hectocotylized," traced to its root, has little sense and less meaning when applied to the reproductory appendage of the squid: freely translated it indicates merely "a hundred cells." I long remained in ignorance of its justification until at last I found its explanation buried in an old book. It appears that originally this word came into use in reference to the condition assumed by the arm in those instances in which its modification was carried out more completely—such as in the case of certain argonauts. In that case the third left arm of the male, during the breeding season, is represented by a sac. This sac bursts and from it extends an arm terminated by another sac from which subsequently extrudes a long filament later to become charged with sperm packets, or spermatophores, removed from the orifice of the generative duct opening within the mantle cavity. During copulation the filament-arm becomes detached at the tip and is left adhering within the mantle cavity of the female by its suckers. When specimens of females were first found with these detached adhering arms, the arm was mistaken for a parasite and named *Hectoco-*

tylus by the discoverer, Cuvier. Therefore, in consequence, the correspondingly modified arms of other cephalopods have come to be called "hectocotylized."

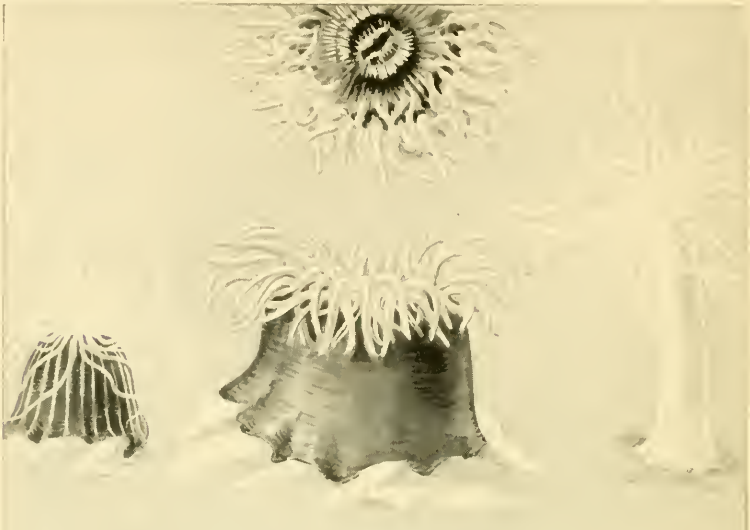
However, compared with the complexity that occurs in the reproductive modifications and methods of the forementioned argonauts, the case of *Loligo* may be called quite simple. The tentacular arms of both sexes are completely retractile and usually are extended only for the purpose of prehension, such as seizing prey. The left ventral of these arms in the male is swollen at the tip and adapted for transferring the spermatophore. This capsule is placed during coitus within the mantle cavity but close to the region of the lower lobes of the buccal membrane. Soon after mating, the female lays her eggs. When the eggs are deposited, the sperm packet is ruptured, releasing a cloud of spermatozoa to effect fertilization. The club ends of the tentacular arms are furnished with four rows of sucker-cups; the stationary, or sessile arms are furnished with but two rows. In the last-named appendages, the cups line the whole length of the inside of the arm, each cup being pedunculated, or set on a short stalk. A slight fringe, or so-called swimming-web, is at the margin of all the arms except the two lowermost pair.

I have just referred to the siphon. The cephalopods are equipped with perhaps the most unique mechanism in Nature for achieving locomotion. The vital parts of the squid are enclosed within the mantle which is attached along the back and which except at the line of attachment forms a freely hanging bag. From the mouth of this bag projects the head and tentacles, and underneath these the short tubular organ known as the siphon. With the expansion of the mantle-bag, water is drawn to the interior through the slit-opening around the sides of the neck, and passes over the paired gill structures on the body within the cavity. If the creature be quietly resting, the water is expelled through the same orifice, and this constitutes its normal method of breathing. But if it essays to swim, the free edge of the mantle engages with the outer wall of the siphon, in this way closing the slit; thus the water is forced through the siphon, propelling the squid in the direction opposite to that in which the siphon is pointed. This direction is usually backward so as to avail itself of the advantage offered by the

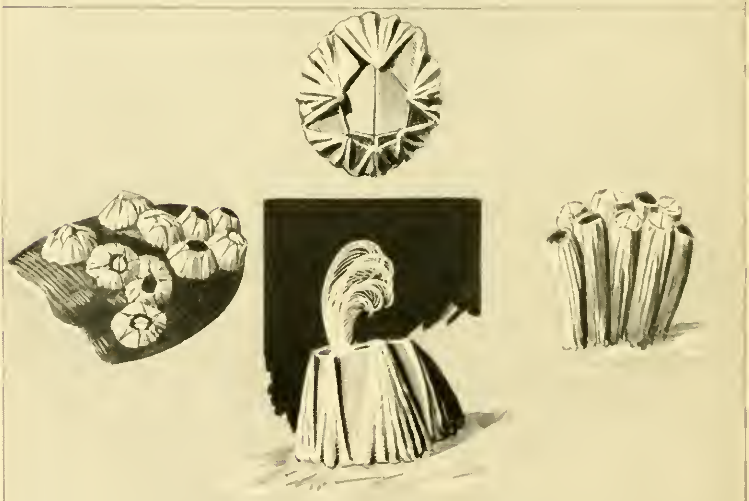


THE SQUID

Detail of tentacle
Siphon
WILLIAM CROWDER



SEA-ANEMONES



BARNACLES

stream-lines of its shape. Decreased frictional resistance also results in trailing the arms behind. Here, then, we have a sort of animated syringe: in short, the squid has solved the locomotor problem not by swimming as a fish or becoming a paddler, but by making of itself virtually a hydraulic apparatus.

Another fact should be touched upon here; although I shall have occasion later to refer to it more fully. The squid, unlike certain fishes, is not in hydrostatic equilibrium with its surrounding medium. It can, and usually does maintain itself at any level while resting, by a slight undulatory movement of its broad tail fin; but if such movements should cease the animal would sink at once to the bottom. In this it is like large crustaceans and other creatures generally which are without an air (or gas) bladder. Lithocysts, or balancing organs, are present, however, and with the aid of these it holds its position relative to a horizontal plane.

The striking color changes which the squid manifests under excitement and even at times when there are no outward provocative causes, are owing to the numerous pigment cells immediately under the animal's skin. Each cell, or chromatophore, is provided with muscular walls; contraction of the walls causes the cell to diminish to a microscopic dot, making it practically invisible; their expansion, however, is followed by an enlargement of the cell area fully to twenty-five times. There being several sets of these chromatophores—amber colored, blue-green, and reddish-brown—and each set having the power to expand independent of the others or in conjunction with them, an extraordinary range and variety of hues can be produced. These pigment cells function throughout the life of the squid, and their activity can be observed while the creature is still contained within the egg. It has been supposed by some that they may afford concealment for the owner. It is probable that at one period in the history of the group, concealment was the primary business of the chromatophores; but at present they seem to function for a different purpose. The squid makes no attempt to hide itself from its enemies or its prey by simulation of its surroundings; on the contrary, its chromatophores often betray its excitement and make it exceedingly conspicuous. Sexual activities are particularly prone to engender these exhibitions of chromatic contrasts; and during the mating season, the affectation of conspicuous coloration is most marked, particularly among the males. As a rule, however, *Loligo*, unless under sexual influences or strong emotional stress, remains for the most part pallid. Its prevailing color is a peculiar pearly paleness which confers upon it a translucent appearance.

As may be suspected, the sight of the squid is keen. The fixed forbidding stare which distinguishes its large eyes, is really the result of a marvelous adaptation in so lowly a mechanism of sight. Notwithstanding their seeming structural likeness, the eyes of this animal bear but a close accidental resemblance to those of backboned creatures. They are lidless, though they have a lens, transparent cornea, and retina; but the latter, lining the eye-cavity, is not turned inside out, as in the case of vertebrates—it receives the light directly.

For purely protective purposes, for concealment from, and the confusing of its enemies, *Loligo* relies on its ink bag. The duct of this organ opens into the intestine near the vent. When the squid is startled or takes alarm, it ejects through its siphon a portion of the highly concentrated ink which spreads out cloud-wise in the water, much in the same manner as the smoke screen so efficiently employed by naval vessels—and to the same end: for this darkening of its surroundings not only disconcerts an attacking foe, it also allows the squid to escape under the cover of its obscuring density.

But there is another remarkable function which this peculiar organ seems to possess. Although such a function cannot be ascribed with certainty to the ink bag, it is not unlikely that it acts as a scent gland. The strong odor of its contents and the animal's highly developed olfactory organ partially indicate this assumption. More convincingly indicative, however, is the fact that squids are well known to travel in great schools and close formation even on the darkest nights and at depths to which the light of day can never penetrate. Moreover, solitary squids are seldom encountered; invariably the presence of a single individual implies that a numerous crowd is in the near neighborhood. Now, notwithstanding that the sight of the squid is keen, as an eagle's is keen, the structure of its eye is such that it precludes the possibility of seeing to any great extent in the almost total daytime darkness of the depths or the gloom of moonless nights; the eye cannot accommodate itself as can, for instance, the eye of a cat. Therefore the maintenance of so close an association in these circumstances plainly implies the possession of another contactual aid by the individual than the sense of sight. That this is scent, it is patent. That its seat is in the ink bag, it seems quite certain.

V

Elsewhere in this volume, I have given some account of how I once came upon the egg capsules of *Loligo*. The eggs were contained in cocoons which composed a cluster of fifteen spindle-shaped, jelly-like masses, each measuring about four inches long by one half inch in largest diameter. Each cocoon was attached at one end, in conjunction with its neighbors, to a seaweed; and the eggs in each numbered nearly one thousand.

Space again precludes any elaboration upon the details incident to the development and hatching of the young in the environment of the laboratory. The various minor changes in the transformation of the embryos would be interesting to dwell upon; but, after all, these changes are wholly technical and needless to recount for the purpose of this paper. Suffice it to say that I watched my new-found fry with unremitting attention for an entire month. During this time, the major alterations were chiefly represented by a gradual growth of the embryos which after the first week became more adult-like each succeeding day. Development was direct, there being no "veliger," or free-swimming, stage such as marks the metamorphosis of the clam and other familiar mollusks. At the end of this period, the young, now about an eighth of an inch long, escaped from the disintegrating capsules; and I then decided to return them to the sea.

My decision was prompted partly by expediency. Obviously it was impossible to keep alive for long in the restricted quarters of the laboratory ten thousand or more squids. They were now tiny, but as voracious in their way as their elders. Unless supplied with a plentiful portion of their proper food they could not thrive; yet with sufficient to eat, they were so fast-growing that they would soon suffer for want of room. But also was it so decided because I believed that I had learned about all that this creature had to reveal, that I had nothing further to find in the way of its behavior.

Observations eventually extending over many seasons taught me much indeed. I learned that the squid is short-lived—probably living for four years at the most; that from hatching to the adult age, notwithstanding its protective appearance, its method of obscuring itself with its ink, its power as a swimmer, it is the frequent and favorite food of many large fishes; that the female probably mates but once during a summer, yet deposits several batches of eggs totaling more than fifty thousand.

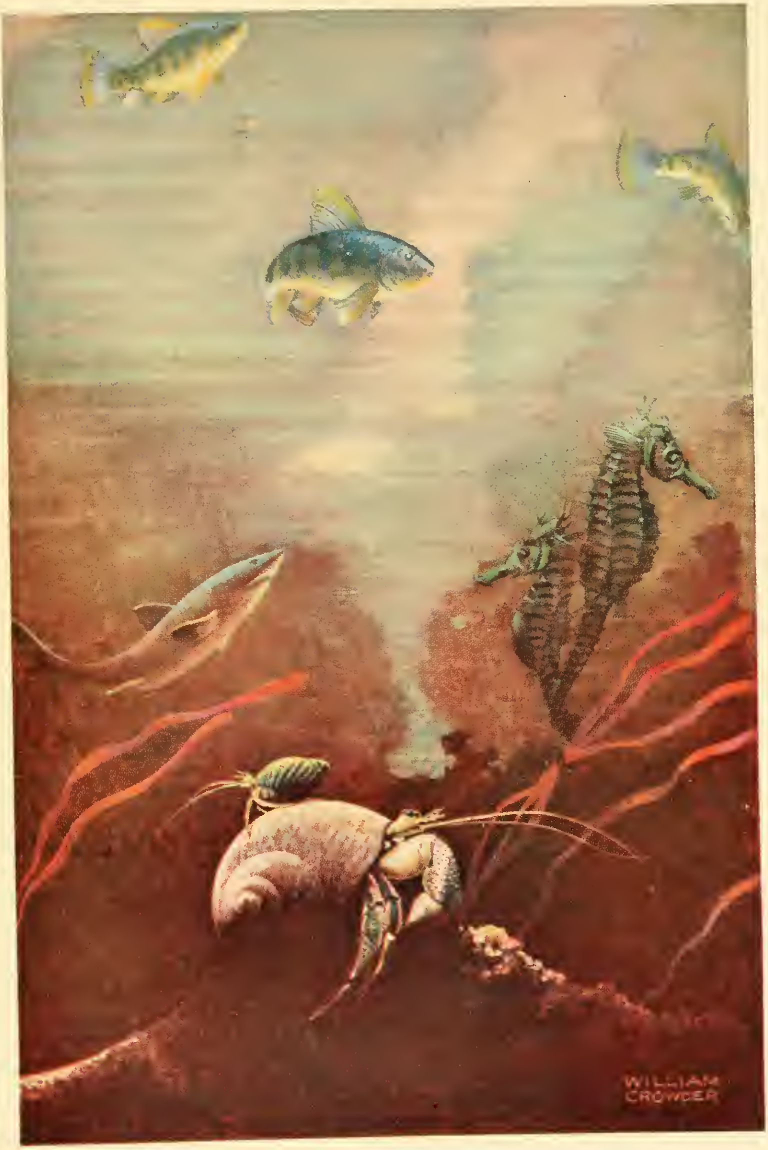
And who that pretends to follow the profession of naturalist could review such achievements of fact without a feeling of complacent finality? I hesitate to picture my own species of smugness in this matter. My self-satisfaction, however, was not to endure. I was eventually to arrive at that stage of despair, common to the experience of every naturalist, in which, previous familiarity notwithstanding, it becomes only too evident that any real acquaintance with the subject has only barely begun.

And this reaction was brought about by a discovery made in circumstances wholly unrelated to the direct object of research. It occurred, in fact, during a period of relief from the exactions of my work. I presume that I am capable of experiencing to the fullest measure all the joys of creative work and of those employments of the naturalist which might aptly be termed the routine labors of love. There come, notwithstanding, times when after prolonged and intensive application, both mind and body yearn for a respite, when the reek of reagents, the smell of paint, the stink of ink begin to pall. My usual recreational recourse at such a turn is to lose myself in the solitude of a neighboring swamp or woodland and become buried in a favorite book; or else it may be that I will take the *Hippocampus* for a short run out into the harbor where with the engine stilled I drift idly about, while sprawled out in languorous ease on the forecastle deck I am carried away on the magic carpet of the cabin radio.

Behold me then on an August night, at the close of a sweltering day in the studio-laboratory, aboard my boat, supine, staring into the spangled space above, and thrilling, not to the sight of the

SALT-WATER LIFE NEAR THE SHORE

Cyprinodon: a killifish (top-left, top-right, and upper-middle)
Carcharias: the sand-shark (middle-left)
Hippocampus: a sea-horse (middle-right)
Pagurus: a hermit-crab (lower-middle)


WILLIAM
CROWDER

SALT-WATER LIFE NEAR THE SHORE

stars beyond, but to that inward vision wrought by the strains of some symphonic broadcasting orchestra in a superb rendition of the "Evening Star" from Tannhäuser. Then follows the sweet, weird, affecting melody of Rimsky-Korsakoff, the "Song of India," succeeded by the strange yet ravishing lyricism of Gershwin's revolutionary masterpiece, the "Rhapsody in Blue." Thus enjoying the music in the absolute silence of the watery expanse—as music only can be most enjoyed—I listen to the program to its very end.

The moon is risen, but is not yet high. Black patches appear in the firmament near the eastern horizon—invisible clouds blotting out the stars—and an occasional film creeps over the face of the moon dulling the brightness of the reflections in the long-reaching lunar trail. These details, however, are only vaguely registered, my mind for the most part being sensitive only to that which strikes the ear—an ear probably perverted, since I am utterly unable to endure the usual tribe of soprano or baritone soloists, holding that most of the former and all of the latter should have been strangled at birth. And I gather from the words of "your announcer" that it is one of these who will now desecrate the silence. But I vow it shall not be if I can reach the radio first.

Barely do I rise when *plop!*—something which I take for a fish falls at my side flush upon the deck. The spell of the receiving set is now utterly broken. No longer am I the hedonist; I am become the naturalist once more. When finally I give my attention to the instrument, the soloist and indeed all succeeding performers will have long since been off the air . . .

I hastily secure a flash-light and play its brilliant beam upon the spot whence came the sound of the supposedly fallen fish, and am greeted with the sight of a full-grown squid. Water wets the deck for a considerable space around, showing that the helpless creature had made a desperate and supreme effort to regain its proper element by exhausting in one discharge the contents of its mantle cavity. Yet it continues the rhythmic operation of breathing, and the sound as of a straining asthmatic gasp comes with each diastolic impulse. Blushes of deep orange pass over its body in waves; but the contact of my hand as I move to return it to the sea immediately causes an intense stain of

Indian red to spread out from the region of my touch.

From the appearance of its tentacular arms I ascertain that the specimen is a female; and I am reminded for the moment of how almost on this very spot I previously came upon the eggs of this creature in my trawl—but now the *Hippocampus* had drifted well out of the harbor. Also it had been in this locality that I liberated the young. What was their fate? Some, no doubt, early became the prey of larger creatures; some escaped for a while only later to succumb; others more fortunate attained to maturity. Only a small minority, however, were lucky enough to live out their allotted span.

As I drop the now nearly exhausted squid over the side, I try to follow it with my flash-light, but it darts swiftly out of sight into the blackness out of the reach of its rays. The searching beam, however, picks up other forms which despite their indistinctness, I recognize as creatures of the same kind. Scores of squids resolve out of the dark depths, then specter-like dissolve into the nothingness of the watery background. But hold—one creature comes tail foremost straight toward the surface. Nor does it turn when nearing the top. It breaks water, hurtling a foot or more into the air, falling back fully a yard from where it emerged. So close to the *Hippocampus* has its impetuous dart and following plunge occurred that the flying spray strikes my face and I taste the salt from the tiny rivulets running down my cheek.

Instinctively I look for the cause of this curious maneuver. But no tangible evidence of a pursuing animal is forthcoming.

Now completely fascinated by the presence of the squids, I continue to watch. It is obvious that I have drifted into a considerable school. Better to observe their actions, I lie prone on the forward deck which is flush at the bow, and adjust the light so that the angle of its rays covers a large area. Numerous small crustaceans are attracted; but the light draws not a single small fish—these latter animals seeming to be well aware of the catastrophe that awaits exposure in the circle of illumination. Occasionally I hear a splash coming from the outer darkness, caused undoubtedly by the rising of some squid. Then within plain sight, but just without the lighted area, appears a living rocket, a creature glowing with phosphorescence; and as it shoots above the surface its siphon spouts a stream of water which falls like a shower of shining sparks . . . It is at this conjuncture that I am overwhelmed with mortification.

After all, how little I really know about *Loligo!* Behind this apparently purposeless yet mysterious behavior, there must be some important but commonplace cause. What is that cause? If this can be determined, doubtless it will reveal not a few of its other actions in a new and unsuspected light.

It is one thing to observe a fact; it is quite another thing to interpret it. It had been seemingly simple to deduce the probable length of the squid's life partly from the fact that this mollusk belongs to a phylum, the other members of which are notoriously short-lived, and partly from the circumstance of its periodic or triennial abundance. On an average of every three or four years, this Long Island Sound variety shows that the maximum increase in the numbers of adults is an almost certain prelude of a season following in which they exhibit the greatest scarcity—an order of occurrence indicating only too patently that it bears some relation to its length of life. Nor had it been less conceivable from the fact that females are found with spermatophores sufficiently numerous to supply an entire season's deposit of eggs, and from the additional fact of finding adult males with spermeries exhausted early in the summer, that no more than a single mating was necessary to insure fertile eggs for the rest of the year. But what construction can be put upon this species of behavior that now presents itself?

I recollect most vividly all that I have ever read and heard coming from other observers regarding this and its related phenomena: ranging from scientific reports to fishermen's tales of how these creatures precipitate themselves by thousands upon the beach to perish or how they singly have been seen to sail like flying-fish over long distances in the air. And I frown inwardly as I reflect that the most improbable and absurd theory to account for this singular action has been advanced by the scientists themselves. For according to my brethren of the books, the squid is presumed to throw itself out of the water because it is attracted by the moon!

An explanation of those instances wherein this selfsame singularity manifests itself on moonless nights, seems not to have been recorded.

Although I am unable to share this superstition, the mystery of it all becomes no clearer. Long do I ponder the matter, and without results; thus becoming more and more disturbed with the realization that I yet have much, very much to learn about *Loligo* . . .

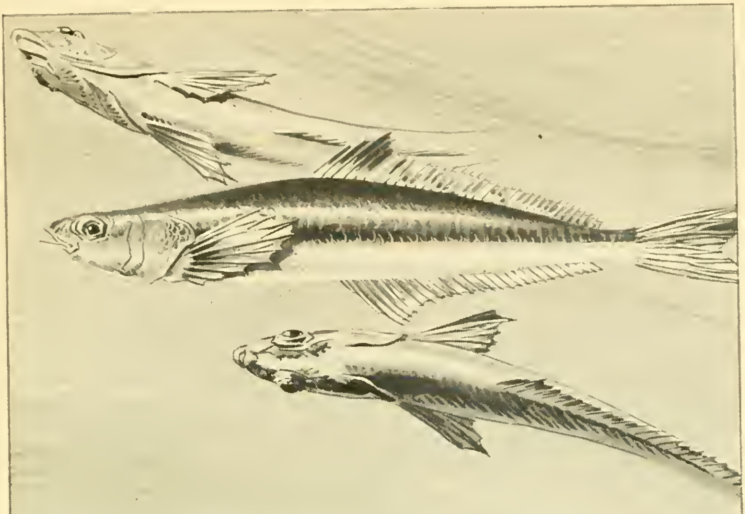
The light from my electric flash-lamp eventually grows dim; I snap it out but remain peering down into the darkness. The phosphorescence has disappeared. A light wind has now risen, and soon a drop of water falling on my hand tells me that my loafing period is at an end. Overhead, not a star is to be seen. Rising to my feet at last, I go into the cabin for my oilskin, and note by the clock that the hour is long after one.

VI

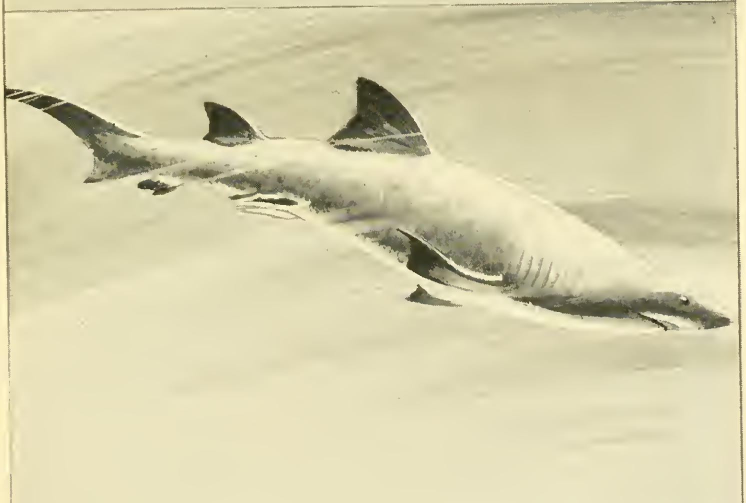
Returning home through a driving rain, I straightway make for my laboratory upon my arrival.

I do not stop to take off my sou'wester and other dripping outer garment, but proceed at once to a shelf from which I remove a two-quart kitchen preserving jar containing what to the ordinary eye might appear to be a mass of potted tripe, but what in fact are the pickled remains of a dissected squid. With a long forceps, I dip into the solution and fish out one by one all the fragments and lay them in a certain semblance of orderly relationship one to another upon the work-bench. Passing a large hand-lens in a swift survey over the various details of organs and of general structure, I make a mental review of those examples of their coördination in the living animal, which are now uppermost in my mind . . . Yes, my previous findings are confirmed. *Loligo* is without any trace of any organ that maintains it in hydrostatic equilibrium with the water. And, although sooner than I had reason to suspect, I think that I am actually nearing the truth.

Presently, indeed, the mystery clears away—at least as much of it as logic and applied common sense are able to dispel. I smile at my simplicity. *Loligo* leaves the water unwillingly and at night-time because in the darkness it cannot see. Other rapidly moving swimming creatures possessing an air bladder are thereby equipped with an organ



THE CRAB-EATER



THE SAND-SHARK

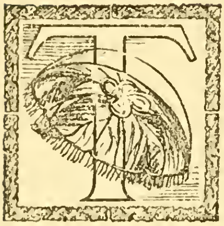
WE LOOK OVER THE HAUL OF OUR SEINE

extremely sensitive to depth pressures. It is through the aid of this organ, and not by means of the organs of sight, that they are enabled to determine their nearness to the surface. That the squid is without such an organ or its equivalent, is certain; thus, not being aware that it is so close to the top, in its blind rush it propels itself clear of the water—oftentimes to precipitate itself in enormous numbers upon the sandy shores and rocks.

CHAPTER TEN

Aurelia: A Monograph of the Moon-Jelly

I



THERE are some who shudder at the mere mention of the word jellyfish. . .

To the true lover of Nature, no living creature can long appear ugly: eventually it acquires a certain æsthetic charm. He will best understand this statement who knows *Aurelia* (*A. aurita*) not as does the casual bather to whom it is nothing more than a soft and slimy shape, not as does the inland dweller on some rare visit to the shore where he sees a being from an unknown realm, which he regards with that peculiar dread which is created in the mind of the unknowing by every queer and unfamiliar form, but who knows it as a vital throbbing entity, gracile and classic of outline, beauteous and resplendent as the sparkle of silk as it disports itself at the surface of a sunlit sea, or as a lovely living light when, like a comet crossing the phosphoric drift of the Milky Way, it sweeps past in the night shining with its own luminescence—who knows *Aurelia*, in short, as it really is.

For my part, I know that I shall always hold for it an unbounded admiration; nay, a deep affection. It was one of the animals that first enticed me to attend and to interpret the drama beneath the waves.

And I fain would fondly indulge in the pleasing memories of those wondrous hours, watching with sheer sustained excitement the subtle changes of the moon-jelly's eggs and the transformation of the larvæ; fondly would I linger, too, over the recollection of innumerable golden days afloat when first I beheld the Scyphomedusan myriads moving with the silent tide.

As these lines are composed, it is in the dead of winter. I pause in my writing to look around the room. It is not yet dawn; others are still asleep. But the tank-laden tables, the littered bench, the collection-filled shelves, my dog, my drowsy macaw and mischievous crow are utterly lost for the nonce to my unseeing eyes. My attention is riveted to the past; my thoughts are of other times and of other seasons. I rise . . . the scraping of the chair startles the stillness of the early hour . . . for one fleeting moment I am recalled to the present. Going to the frost-streaked window I see the transparent sky glitter like the far-off flood of a noctilucent sea. And that star of the morning which glows like another moon rises over the eastern hills, and its coruscating image I see reflected from the frozen surface of the cove. Once again I am soaring on the wings of fancy. There comes the smell of damp and stranded seaweed, the musky odor of the swamps, the sweet and balmy scent that filters through the cedared valleys of Long Island. Autumn is here, also the bright blue sea . . . and *Aurelia*.

The time is late afternoon in October. At the thwart of a little rowboat, I am engaged in going over with a curious eye a various population which all but completely covers the crumbling framework of an old and partly submerged wreck. Mussels and barnacles have for the most part preempted the available surface of the rotting hulk, but here and there, exposed by the falling tide, are also to be seen the flaccid forms of seaweeds and hydroids, anemones and starfishes, and other objects which make up the more colorful part of the living mantle that drapes the dripping hull.

Then darkness finally comes, bringing in its train a most striking phenomenon. The tide has turned. A heavy mist arises. Out of the sable void the waters of the incoming current flow silently, swiftly, luminously: a ghostly stream, a river of sulphurous light! For a space I sit in my anchored boat, transfixed by the eerie splendor of the night. I seem to be sailing over a milky sea glowing with soft throbbing flames of phantom-fire. Pale patches of glaucous light swirl past, losing themselves in eddies of vaporous blue. Now some scintillant point of purple incandescence pulsates, suddenly flares, then as suddenly dies out. Diffused delicate flashes of a seemingly unearthly hue appear to pervade the water on every side; and as they glide by, mysteriously, vaguely, looking unreal, I am lifted from the world and hurtled through space . . . The planets, the stars, even those mighty universes of cosmic reaches swim before my spell-bound eyes. No longer am I a human, a very mortal being. I am non-existent. I am become as nothing —without form and without substance. Time and space for me are ciphers. I am drifting——

The world forgetting,
By the world forgot

in a delectable region, in an indescribable realm of sweet illusion.

The mist begins to clear, and as it slowly dissolves, the skeletal outlines of the ancient hull loom black and indistinct in the vastness of the night. Still it is not the vision of the shadowy timbers that arouses me from my fantasy, it is the sight of the cloak of ambient fire that invests the hull below the water-line. Doubtless this submerged portion of the framework glows with a phosphorescence of its own; but the light of this luminescent host of little forms swarming in the worm-infested labyrinths pales to nothingness beside the brilliance of the tide-born multitude of larger light-producers impeded by the wreck. Like a specter ship it gleams: every rib and bulkhead is easily marked in the depths of the fiery flood. Like live embers fanned by a fitful breeze, her outlines glow intermittently—there are fleeting flashes of mauve, and ambiencies of azure and of deep indefinite green—and they grow tremulous with a warm and friendly light, a light made up from the flashes of a hundred thousand jellyfishes!

Making free use of my dip-net, I soon have the half-barrel at the bow of my boat filled to overflowing with the animals. They swim around in agitation, emitting violent bursts of flame, making the tub glare like a cask of liquid light. Examining them in the rays of an electric lamp, I find that the jellyfishes are of three kinds. The first to arrest my attention is a large semi-transparent creature of about the diameter of a dinner plate. On coming into contact with the tentacles of this animal, my skin quickly apprises me of their peculiar nature, and I recoil from their caress. A sharp, prickling, burning sensation galvanizes the muscles of my forearm; but brief as is the torturous touch, I retain the livid marks for hours after. This jellyfish I recognize as *Cyanea*, the "sea-blubber."

Then I see a number of somewhat similar though smaller forms. These are *Aurelias*, pretty individuals well deserving the name of "moon-jellies." They are, when viewed from the side, like flattened hemispheres; when viewed from the top they are circular and about the size of a soup-bowl. Indeed, in some respects they may be likened to inverted bowls of glass, as it is with the bowl upside down that they propel themselves through the water. Within an outer transparent dome is another dome less arched but equal in diameter with the first and joined to it throughout the extent of the rim. The rim is notched at eight equidistant points, thus dividing the periphery into eight lappet-like structures, each lappet bearing a fringe of numerous thread-like tentacles less than a half inch in length. The tentacles are harmless to human touch. In decided contrast with the exceeding transparency of the outer dome, the inner one is opaque and of a bluish milky white. It is marked with numbers of confluent vein-like channels extending radially from the central region at the top —a region which in this animal is distinguished by the most curiously shaped structures of any jellyfish. These structures are the peculiar horseshoe-shaped gonads, or sex organs. They are four in number, and are placed with their open ends facing the center. It is by these bright-hued and prominent organs that *Aurelia* may easily be distinguished from all other jellyfishes.

Now naturalists call this bowl-like part of the jellyfish the "umbrella"; and it is surely a shape more representative of that homely article than it is of the fancied "disk" with which the earlier observers were wont to liken it. The umbrella is at once the swimming appendage and the mantle or covering for the so-called stomach and internal organs. The comparison may even be extended: for depending from the central region on the under side, are four veil-like folds of tissue, the length of which equals a little more than the radius of the umbrella, and these are much in the position of the handle and shaft of an umbrella. And somewhat in the manner of the alternate opening and closing of an umbrella, does the jellyfish swim. Perpetually pulsating (it is a systole and diastole that does not cease until the animal's death), it sustains itself at various depth-levels or travels hither and yon at will.

I soon discover that the sea-blubber and the moon-jelly are not the only light-producing forms within my tub: in fewer numbers, but with an intensity of light seeming to surpass even that of the large jellyfishes, is a smaller form that for beauty of textural tints is positively without parallel. This is the comb-jelly. No bubble blown is more splendidly iridescent. Diaphanous—transparent almost as the very water in which it swims—and apparently with the merest trace of substance to its body, it fairly flashes with the luster of a hundred haunting hues.

The more colorful areas of its body are restricted to the eight rows of cilia, or minute hairs along its longitudinal axis. It is with the aid of its cilia that it swims—a performance achieved in a very different fashion from that of the large jellyfishes. The hairs are veritable oars, lashing in unison and vibrating so rapidly that the eye cannot catch their motion; as a consequence the cilia seem to be held stationary at various angles to the body, thus forming a sort of resemblance to a comb. It is, in fact, because of this fancied resemblance that there has been given to creatures of this kind the scientific name *Ctenophora*, meaning "comb-bearer."

To the color-trained eye, the sight of the manifold rainbow tints which play over the soft surface of the comb-jelly's body is really ravishing. Nevertheless, it needs no expert vision, no understanding of color-harmonies to become bewitched by such blending of hues. Like the finest in music, like the loveliest of lyric prose, like "feeling" in the painter's technique, it is of an order appealing to all; it is of that order, in fine, the appreciation of which has its root-springs in an experience as old as the human race . . .

II

But in my appraisal of the *Ctenophores*, I do not neglect to note some other details that manifest themselves in the case of the moon-jellies. Among the different sexes, I distinguish a number of gravid females. The sexes are easily differentiated at a glance: the males having gonads of a pinkish cast, while these horseshoe-shaped organs in the female are a bright yellow. Careful scrutiny discloses that the maternal pouches of the females are filled with eggs while the folds of the veil-like appendages around the central mouth are clotted with masses of minute bodies apparently different in structure but of the same cast as the eggs. It is later that I learn that these latter are the planulæ, or larval bodies only slightly advanced in development from the egg stage. Here, then, is an opportunity. Here to hand is an abundance of material such as I most desire for the purpose of extending a research into the life history of *Aurelia*.

My first-hand acquaintance with the moon-jelly has been slight. All my attempts to penetrate the ponderous technical literature pertaining to the animal have been disappointing, not to say dismaying. I have found on consulting the books paralyzing descriptions of anatomical puerilities, but a shocking paucity of information regarding the actual life of *Aurelia.* Much erudition and ingenious speculation has been paraded concerning the reactions of fragments and sections cut out from the living animal; much professorial profundity has been indulged in when tracing in the mutilated specimen its "behavioristic reflexes"; but an almost utter silence is maintained regarding the jellyfish as it lives in the waters of the sea. The truth is, the animal is to these scientific slicers merely a "subject"; the jellyfish, *per se*, is of no interest whatever. Therefore, although I am fully informed by the books as to how a jellyfish will properly pulsate when carved into various pretty and geometric patterns, I am obliged to seek for myself such facts as may pertain to the animal while it is intact and free.

And yet how well I remember the religious awe with which I perused these and other minutiæ of natural science research; how at first I regarded the authors as veritable wizards. But it was not for long. In my own increasing experience, I soon learned a thing or two. Chief among the things learned is that the work of the investigator (contrary to the statements of the savants) does not require a superior order of intellect for its performance—not even an uncommon intellect. I was forced, therefore, to conclude that those worthy gentlemen were not wizards. Indeed, it had become only too plain that what they were able to do, any normal person equipped with determination, a sound pair of eyes and a lucky star, can likewise do. Nor should I insist that even these latter attributes are indispensable.

The importance of this latter element, which is to say the element of chance, cannot be too strongly stressed, because of the all too prevalent belief that the naturalist invariably makes his discoveries by reason of a long, arduous preparation, and intensive study; a belief fostered by the literature of certain pundits, men who would appear most learned by throwing an air of mystery over their methods; thus indicating by example as well as by their statements that a high intellectual development, remote from that of the layman, is essential to penetrate the profundities of their craft.

III

My find of moon-jelly eggs and new-hatched larvæ is ensconced in the tanks of my laboratory. It is now several days since I came across the gravid mothers carried along on that memorable tide.

The weather without is propitious for work neither on the water nor on the beach. Throughout the previous night, the bellowing of the siren on Execution Rock, and the intermittent booming of boat-horns on the Sound, were continuously wafted on the ever-shifting currents of the air. The morning broke darkly; and a gray, gusty, drizzling day prevails.

Still, it is not without profit that I am obliged perforce to remain within. It is withal an opportune period for observation under the sheltering roof of my workroom; it is, in truth, on this day that I am diverted by a sight which is the starting of that momentous series of observations whereby I am finally to obtain the full life history of *Aurelia* from the egg to the adult.

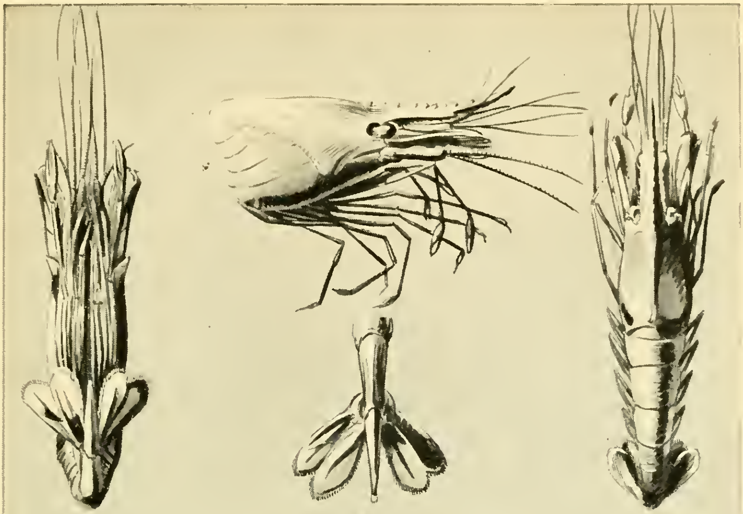
My first glance at the tanks on one of the well-laden tables, discovers what appears to be certain evidence that the water it contains is rapidly, almost suddenly, becoming foul. For, only a few hours previous, the aquaria were transparent, and the mother moon-jellies were swimming ceaselessly hither and yon in the crystal clearness with undiminished vigor. But now, in nearly every case the moon-jellies are inactive, some lying on the bottoms pumping lethargically, others apparently dying or already dead.

Fast following comes another discovery. Gradually the cloudiness of the water becomes concentrated; a filmy haze settles toward that side of the tanks facing the window light.

Now, something of this sort, this blanket-like haze, I have seen before. I recall an instance of some fiddler-crabs whose larvæ broke from the "sponge," or egg masses carried around by the mothers, and swarmed in myriads toward the light. Can it be that this is an exodus of a similar nature? . . . I examine the jellyfishes. Of course! It immediately becomes obvious: the brood-pouches are almost empty, and the creatures' oral appendages are clear as glass. The hazy cloud-like film is composed of the multitudinous free-swimming young of *Aurelia:* a fact which I confirm at once with the aid of a dipping-tube and the microscope.

Under the magnification of a low-power lens, the lively little larvæ are apparently as long, but not quite so broad as my thumb-nail; actually they are smaller than mustard seeds. Pear-like in form, diaphanous, and tinted with the soft appealing color of old rose, they swim across the field of the microscope with their larger, or bulbous, ends foremost. They move in graceful curves, and so swiftly do they go that it is difficult for the eye to follow them. Only when I retard them with a narcotic or by other artificial means am I able to determine how the all but invisible motes propel themselves. Like the downy bloom on blades of wildgrass, there are then revealed innumerable crowded processes, short tenuous cilia, completely investing the surface of the semi-transparent bodies. The rapidly-vibrating hairs are the machinery of locomotion.

For several hours the young creatures continue to hover on that side of the tanks which receives the strongest light. They do not yet seem to assimilate food. Nor does there appear to be any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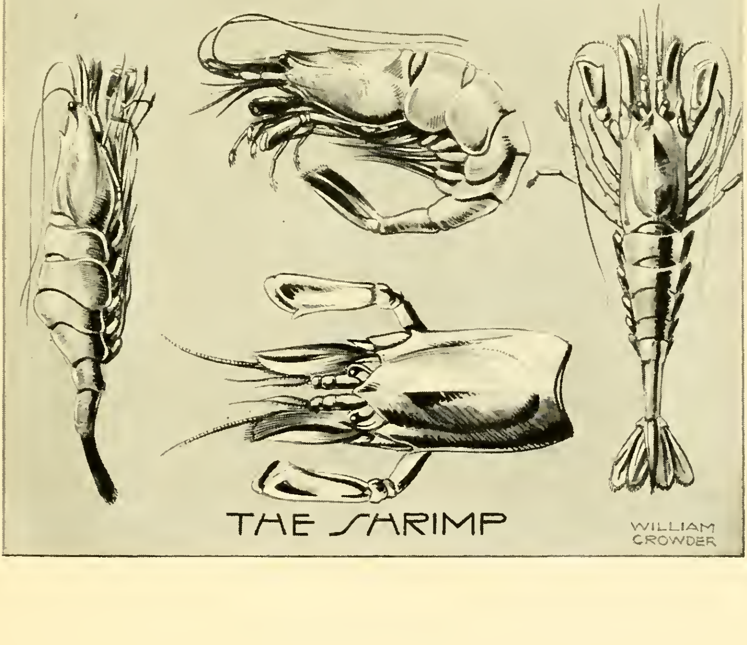
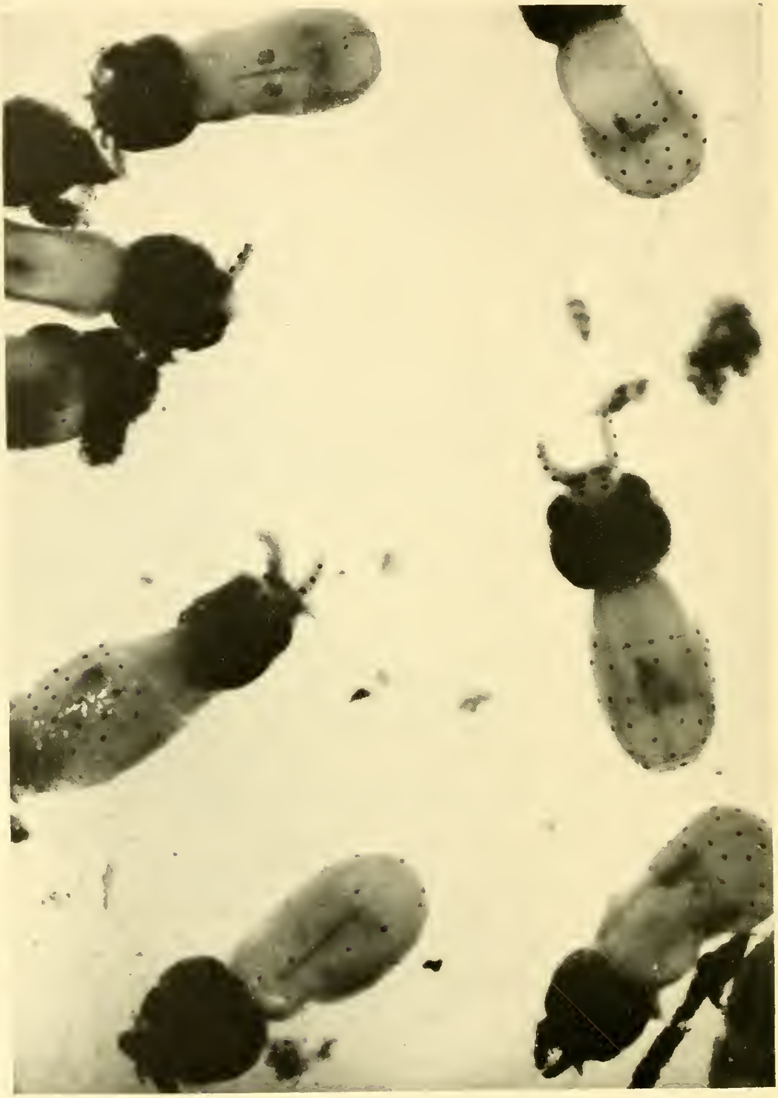

THE SHRIMP

WILLIAM
CROWDER



NEW-HATCHED SQUIDS
Enlarged fifteen times

anatomical provision for this purpose. No mouth, no orifice of any kind can I find which indicates that the animals actually eat. Yet, not only do they pass an active existence, using up much energy in their cavorting career, but they also actually increase in size.

I now set about to transfer some of the water of the tanks to various smaller receptacles: for it is becoming plain as time goes on that the mother jellyfishes will not endure. And their death, entailing as it must disintegration and decay, will be dangerous to the smaller fry; thus threatening grief to future observations.

Barely are my precautions taken before the larval hordes cease swimming and sink to the bottoms of their jars.

Have I, by making this change, unwittingly brought about their end? . . . Are these rovers of the open sea incapable of living elsewhere than in their natural habitat? . . . So for a space it seems. Then I subject the various containers to a careful examination. Thereupon is disclosed the real reason for my dismay.

The larvæ are far from dead. But a decided change, indeed, has taken place in their appearance. Nearly all are altered so that they appear very like a chalice in form; moreover, what is of no small significance is the fact that the altered individual units have attached themselves to the floors and the walls of their artificial homes; this attachment being accomplished by their secreting a firm horny substance, sheath-like and almost completely enveloping the lower half of the supporting stem of the living goblets.

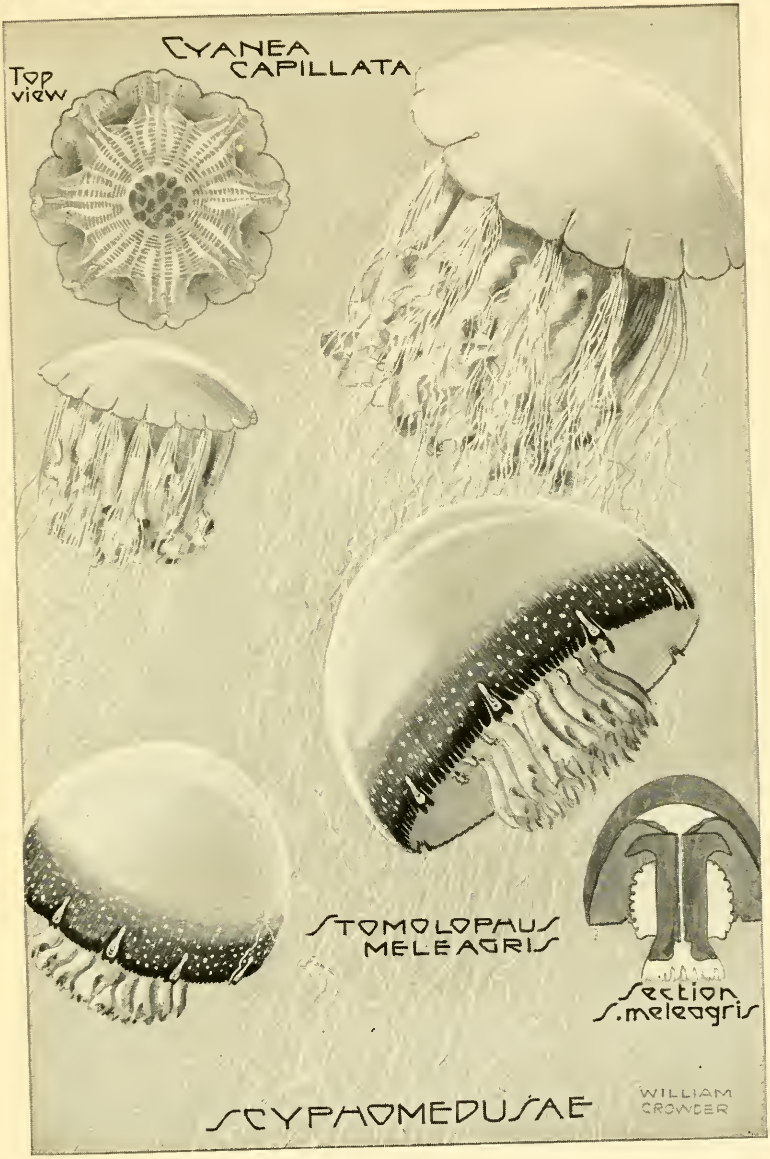
With quickened pulse I watch the transformed animals. And even as I look, further slow and delicate changes take place. Around the rims of the cup-like forms, prominences begin to appear. Finally each larva is adorned with a corona of eight tentacles—tiny thread-like appendages encircling the top, more than double the length of the body. Also an unmistakable mouth now comes into evidence. In the center of an area, or platform lying within the base of the tentacles, a small protuberance shows; this is punctured with a crisscross slit leading to the larval belly.

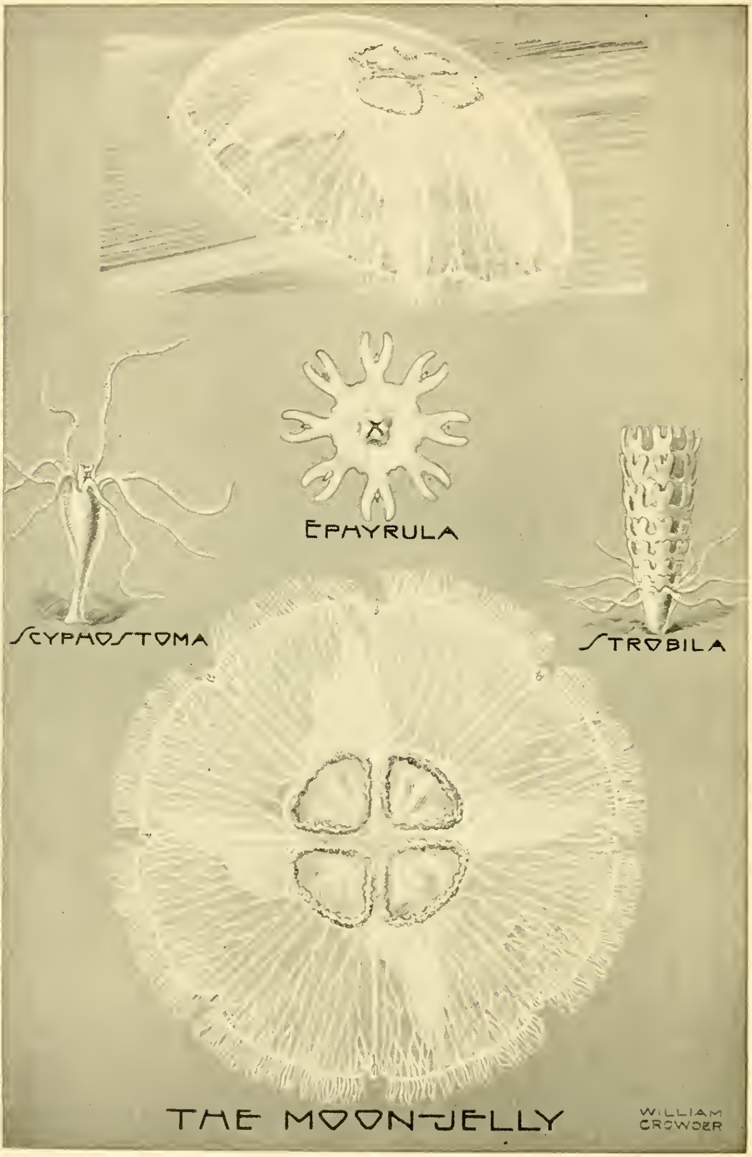
That is all that this day brings forth. For further developments, I must await the future. For the present I am determined to retire; it is well into the night; and I am eye-weary with the hours of close continuous watching at the oculars of my "scope."

Sleep, however, comes not so easily. Ere I have drifted into that desirable existence of shadows and of dreams I have long pondered the meaning of much that I have seen. Indeed, there can be little doubt in any reflective person's mind that the transformations which this young jellyfish stage represents are, by reason of their close connection with embryonic development, among the profound manifestations of Nature. Who can witness without wonder the apparently simple changes which follow the fertilization of the egg—changes wherein a single cell through the operation of chemical and physical forces is caused to multiply itself and to assume a predetermined configuration —changes *apparently* simple, yet, verily, changes of a kind still as little to be understood by the most advanced scholar as by the rudest unlettered native in the hills of Tennessee?

Sentimental philosophers have oftentimes become maudlin over this phenomenon of transformation following the fertilization of the egg cell. Nor, in truth, are its implications lightly to be considered. Yet it safely may be ventured that when our knowledge of living matter becomes more complete, the pronouncement will be that the real marvel exists not in the transformation of the original living cell, but in the subsequent development and growth of the organism. Even so, it is conceivable that there will still be a seemingly fathomless mystery to confront. Certainly few fundamentals appear so remote from our future understanding as the ultimate principle that gives vital substance its peculiar property—whether, indifferently, this property is manifest in a gauzy spray of lowly seaweed or in that most highly organized structure known, the human female.

Bringing the female into the picture is not without warrant in other ways. Every working biologist knows that essentially the male is a needless animal. In Nature, some creatures, such as certain worms, can dispense with the intervention of the males for the purpose of assuring offspring. In the laboratory, too, the male among some other animals has been found to be unnecessary. For example, the sterile eggs of echinoids can be made fertile by chemical means alone. Although in none of these artificial instances does development proceed normally or very far, they nevertheless prove the


CYANEA CAPILLATA
Top view
STOMOLOPHUS MELEAGRIS
Section S. meleagris
SCYPHOMEDUSAE
WILLIAM CROWDER


EPHYRULA
SCYPHOSTOMA
STROBILA
WILLIAM CROWDER

THE MOON-JELLY

point that in the economy of Nature, males are one of its redundancies.

And this being the case, with what greater marvel can we look upon the mystery of the growing egg!

IV

Feeding the many mouths of my strange family threatens to become a problem in the days to follow. The impending difficulty is not that I am unaware of *what* they will eat, but that I know not *how* to feed them lest the method become a serious time-consuming labor—or at best a bothersome routine. I hit upon a plan, however, that solves the difficulty. Once a day I prepare a small measure of a kind of salt-water broth composed of bits of clam, or finely divided crab meat, or maybe flaked fish, and gently stir a portion of this simply concocted soup into the miniature tanks containing the young jellyfishes. After a lapse of a few hours, during which they find their fill from among the floating particles, the water is removed and the tanks are replenished from a clean and wholesome supply, just as it comes from the middle of the Sound.

Little need is there to doubt the purpose of those murderous arms: tiny tentacled creatures such as these subsist almost entirely on still smaller and luckless animals that chance to swim within their grasp; or failing to obtain this living fare, they will seize upon any bits of carrion drifting by. The extraordinary capacity of the tentacles, wherewith these little creatures are enabled to paralyze their prey, is owing to the hundreds of stinging-cells with which these are invested. Under a powerful lens, the cells appear egg-shaped, and each cell contains a thread-like filament coiled in the manner of a spiral spring. One end of this spring is fixed to the cell; the other end is free. And it is charged with an irritant poison (probably formic acid). When any solid organic matter, dead or alive, comes into contact with the tentacles, the cells in the vicinity touched release the coiled darts, and these are driven into the colliding object, numbing or arresting it, whereupon the morsel is drawn to the mouth and engulfed.

Winter comes. Again I am privileged to follow another change in the form of the *scyphistomæ*—for such is the technical name of this stage in the growth of the tentacled young. The singular number of this word, *scyphistoma*, in this instance is useful and to the point, though it may be doubtfully descriptive in other instances where it has been applied by the systematists. It is, in short, a way which science has of saying that the creature in general and its mouth-parts in particular are "cup-like." The countless free-born billions of their brethren who have now found a foothold on the floor of the sea are passing a dormant existence. In the gloom and cold prevailing within the depths during this period, there is a scarcity of food; consequently there is a general lethargy and little growth. But in the more genial temperature of my laboratory where there is no dearth of daily victuals, the case is otherwise. The *Scyphistomæ* are now increased and have attained to a height of more than a quarter of an inch. They are, of course, clearly visible; to study their movements and their major details requires merely the aid of a simple magnifier. The tentacles seem to have shrunk to insignificant proportions; yet the outstanding feature of the animals is the appearance of a dozen or more constrictions which encircle their bodies along the greater part of their length. In every case the topmost constriction is so deep that it would seem almost to sever the terminal part carrying the mouth and atrophied tentacles. I now realize that in this segmenting of the larval jellyfish, I am witnessing what is known as the "strobilization of the *scyphistoma*."

A day or so later the tentacles at the top of each strobila larva are gone. In place of the tentacles is a fringe of lappets, eight in number. The mouth-parts are produced into four veil-like appendages which now function as a food-snare in lieu of the vanished tentacles.

But look! What has happened to the remainder of the diminutive brutes' bodies? The constrictions are so pronounced that each youngster would seem almost to be completely divided into separate thin segments resembling a pile of tiny saucers, each saucer nesting compactly in the hollow of the one underneath. These various saucer-like segments are, in descending order from the top, obviously at different stages of development —each being smaller in diameter than its neighbor above, and resembling less and less the topmost disk until the foot is reached. This lowermost supporting segment is the only remaining one bearing its octet of tentacles.

In this strobila form of *Aurelia*, it is easy to see that what I now have to deal with is no longer an individual organism, or true unit; it is instead a string, or colony, of little jellyfishes, each jellyfish inverted according to its normal adult position, and each attached to its fellow underneath by the central part of its umbrella.

Events now succeed one another rapidly. The topmost unit, or, to call it by its proper name, *ephyrula*, of every column is seized with an occasional paroxysm and suddenly starts pulsating more or less vigorously, after the manner of the adult, seeming as if it were trying to tear itself away from its anchorage to the others below. But these early efforts are to no avail, for the contractions cease as suddenly as they begin. However, the periods of quiescence become fewer and shorter in duration. Eventually the young jellyfish settles for good into a steady, unremitting pumping of its disk; finally it breaks away—at last it starts its long swim, upright after the fashion of its elders, continuing thenceforward throughout its life and without further interruption of the rhythmic movements of its umbrella, like the tireless beating of the human heart.

A close-up of the little *ephyrula* reveals something quite noteworthy. Each baby jellyfish is provided with eight primitive eyes. The eyes are like minute scarlet dots located near the rim of the umbrella at equidistant points and within the forks of the little finger-like lappets which took the place of the tentacles. A small transparent pouch, or hood, protects each eye; and it is because of this protective covering that the members of the class to which *Aurelia* belongs are sometimes referred to as the "covered-eye medusæ." This is the lowest instance in the scale of life wherein the eye appears as a structural organ. It is an eye, however, that probably can distinguish nothing more definite than the contrast between bright light and deep shadow.

By this time, also, a new set of tentacles has made its appearance. Between the lappets and around the under side of the rim they extend in a veritable fringe. They look like short gossamer strands. Their delicate sheen, their silky luster, now of silver, now of gold, is soft, indescribably soft—as might be the subtle reflection of some rare texture spun from moonbeams . . .

V

And such is the memory of my early acquaintance with *Aurelia*, loveliest of the larger medusæ . . . I return to my writing-table, to attempt to revive in words some semblance of the experiences and emotions to that introductory period. But how feeble are the limitations of human language!

The reader, of course, will recognize that this history is incomplete, that the mature jellyfish is not yet. My observations of the moon-jelly, such as I was able to make from the tanks and jars of my laboratory, ended with the free-swimming stage of the *ephyrula*. From that time onward I have never successfully been able to rear them. Continued confinement seems fatal to them: not one of the many thousands I have nursed through their early stages has ever reached maturity. Nor has the sea told me anything which the laboratory has not revealed.

Yet five years went by before sufficient evidence had accumulated to convince me that *Aurelia* had little more to deny, in the way of information regarding its growth and development. Then it was that I came upon the jellyfish larvæ, the finding of which has been detailed in another chapter. By the study of these, whose lives an increased experience had enabled me to prolong, and by piecing together such fragments of information as I had gained in different seasons and on different occasions, I think I have learned with certainty how *Aurelia aurita* rounds out its natural life. Its history can be summarized as follows:

1. In the summer and autumn, the contained eggs of the female are reached and fertilized by sperms liberated freely in the water from the gonads of the male. The fertilized motile egg (called planula larvæ) escape from the manubrial, or mouth-part, folds depending from the mother, and seek an anchorage on the floor of the sea. In this place of security and of even temperature, and remote from the shore where prevails the stress of winter storms and forming ice, they live until the following spring.

2. Before winter actually arrives, however, the larvæ enter the *scyphistoma* stage. During this period they remain firmly fixed to stones or dead shells, seaweeds or other supports, awaiting with languid outstretched arms to grasp with what

THE AUTHOR ABOUT TO DIVE IN SEARCH OF SEA LIFE IN THE INTERIOR OF A PARTLY SUBMERGED WRECK

MY FAITHFUL ASSISTANT

energy they possess those few morsels which filter down through the frigid water at this inclement season of the year.

3. With the advent of spring, changes occur that are relatively rapid in succession. The *scyphistomæ* increase in size: strobilization takes place: soon the *ephyrulæ* are released and the actual metamorphosis is at an end.

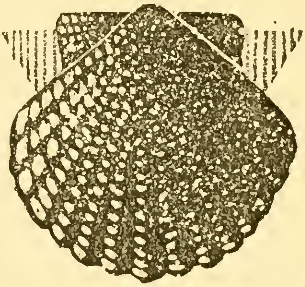
4. The individual *ephyrulæ* are soon of the size of a split pea, are quite transparent, and their filmy tissues are tinted a delicate bluish-green. The gonads are marked but not developed. When the moon-jelly attains to the diameter of a silver dime, it has acquired most of the characters that distinguish the adult form.

5. Thence onward, throughout the spring, the summer months and fall, *Aurelia* continues to increase in size. At the end of autumn it is more than a foot across the umbrella. Still, large and bulky as it may appear, it is astonishingly meager in actual substance, less than five per cent. of the animal being constituted of solid material. This is to say that the jellyfish is nearly one hundred per cent. water.

6. *Aurelia* is comparatively short-lived. Seldom

or never does it pass beyond the year in which it is freed from its larval form. Indeed, great numbers of them seem not to endure beyond the autumnal storms. On these occasions, after a brief but gorgeous existence at the surface of sunny seas or coursing in the perpetual peace and calm which reign in the cool and shadowy depths, they are destroyed by millions, their soft gelatinous bodies being torn asunder or dashed upon the shores to perish.

Still in their death there is a compensation. For in dying they disintegrate; thus releasing numberless unborn young to grace again the grottoes of the deep and later by their luminescence to decorate the darkness of the summer night.



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